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PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and/or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

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SUMMARY

On July 16, 1993, the National Institute for Occupational Safety and Health (NIOSH) received a joint request for a health hazard evaluation (HHE) from the U.S. Forest Service employees and management. This HHE request was submitted because of employee concerns that workers on tree-marking crews were experiencing an increased number of miscarriages and children born with birth defects. Additionally, workers were reporting that the use of some brands of tree-marking paints were causing respiratory irritation, nausea, vomiting, headaches, and fatigue. In response to this HHE request, NIOSH representatives conducted an industrial hygiene evaluation of current work exposures and practices and an epidemiologic evaluation of adverse reproductive outcomes among women of reproductive age within the U.S. Forest Service.

Industrial hygiene surveys were conducted on the Oconee (Georgia), Kisatchie (Louisiana), Gifford-Pinchot (Washington), and Wallowa Whitman (Oregon), National Forests. During each site visit, we observed work practices, and collected full-shift area and personal breathing zone air samples, bulk samples of the paint, and pre- and post-shift urine samples from tree-marking crew members. Sample results indicate that tree-marking crew members are exposed to low levels of mixed solvents and some metals from the solvent and pigment fractions of the tree-marking paint. Although all measured exposures were below the Occupational Safety and Health Administration (OSHA) permissible exposure limits (PEL), the exposures appear to be sufficient to produce central nervous system symptoms reported by the employees.

We evaluated adverse reproductive outcomes among Forest Service personnel by mailing a self-administered questionnaire to approximately 10,000 full-time women workers who were within the age range of 18-51 during the ten-year period 1986-1996. Participants were asked whether they had used a variety of work-related and non-work related materials prior to each pregnancy during the study period. Fifty-nine percent (6080) of the women surveyed responded to the questionnaire.

Because of the relatively low response rate (59%) and the lack of personal exposure data among the study respondents, the results of this epidemiologic must be interpreted with caution. Given these limitations (see discussion section) the epidemiologic study of adverse reproductive outcomes indicates that work as a Forester was associated with an increased likelihood of miscarriages (Odds Ratio [OR] 1.42, 95% CI: 1.06, 1.90) compared with all other jobs combined in the Forest Service. Furthermore, the likelihood of miscarriage increased among women who reported using Nelson paint (OR=1.81, 95% CI: 1.21, 2.70); Southern Coatings Boundary paint (OR=2.77, 95% CI: 1.11, 6.88) and herbicides (OR=1.82, 95% CI: 1.00, 3.32).

Work as a Forester was associated with slightly increased odds of having a child with a birth defect (OR=1.17 95% CI: 0.0.85, 1.63). Households where both parents were Foresters were more likely than households where only one parent was a Forester, or households where none of the parents were Foresters, to report having a child with any birth defect (OR= 2.00, 95% CI: 1.04, 8.08) and possibly more likely to report having a child with a heart murmur specifically (OR 4.66, 95% CI: 0.88, 24.53).

Industrial Hygiene Study

Although exposures to individual solvents were below occupational criteria, the combined effect of mixed solvent exposure may be responsible for some of the acute symptoms experienced by employees when exposed to tree-marking paints. As a result of the Industrial Hygiene surveys, we recommended that the Forest Service investigate using alternative tree-marking paint. High solids, low solvent or water-based marking paints such as acrylic latex enamels should be selected and field tested. Low solvent or water-based paints that are found to be less irritating to employees and do not cause acute central nervous system health effects should be made available for employee use.

Epidemiologic Study of Adverse Reproductive Outcomes

We found an increased risk of miscarriage associated with self-reported exposure to specific tree-marking paints, and an increased risk for birth defects in families where both parents reported being Foresters. However, this study was unable to determine whether miscarriages or birth defects were caused by these exposures. Although the paints currently used for tree-marking did not appear to increase the risk of adverse reproductive outcomes, we recommend that the U.S. Forest Service Foresters continue to seek the least hazardous method of marking trees. If paint systems must be used, the paints should have the lowest levels of organic solvents and toxic metals as possible. Additionally, old supplies of Nelson or Southern Coatings paints should be collected and properly disposed of, and Foresters should be reminded that proper personal protective equipment should be worn while handling paints and solvents and when applying any of the many pesticides or herbicides used.

Keywords: 0851, Forestry Services, Paint, Reproductive Outcome, Miscarriage, Birth Defects, Solvents, Heavy Metals, Foresters, Spontaneous Abortion, Pesticides, Herbicides,

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INTRODUCTION

On July 16, 1993, in response to employee concerns that an apparent cluster of birth defects and miscarriages among Foresters may have resulted from exposure to tree-marking paints, the U.S. Forest Service (USFS) requested that National Institute for Occupational Safety and Health (NIOSH) conduct a health hazard evaluation (HHE) of the potential reproductive and irritant effects associated with exposure to tree marking paints. On February 15, 1994, representatives from NIOSH met with employee and management representatives of the USFS to discuss steps taken to date by the Forest Service to address employee concerns, and visit the Gifford Pinchot National Forest to meet with members of a tree-marking crew who demonstrated the tasks and materials used when marking trees for a timber sale. As a result of this site visit, a HHE was proposed that included: (1) an evaluation of selected tree-marking crews to determine their potential for exposure to respiratory irritants, and (2) an epidemiologic study of women in the Forest Service to determine whether women Foresters were at increased risk of adverse reproductive outcome.

At the conclusion of the HHE, notification letters were sent to each of the workers who participated in the industrial hygiene evaluation. These letters detailed the laboratory findings of the biological samples collected during the industrial hygiene field visits. In addition, an interim epidemiologic report was prepared for the Forest Service and presented during a meeting in August 1997. This meeting was held at the request of the NIOSH project officer to discuss preliminary epidemiologic findings. Forest Service management attended the meeting, and employee representatives participated by phone.

BACKGROUND

Work As a Forester

The USFS has the responsibility of managing the health, viability, and sustainability of the nation's forests. Additionally, it is the responsibility of the Forest Service to manage forests as renewable resources and thereby oversee the activities of those who harvest trees (logging activities) within the National Forests. The activities and exposures of specially trained Forest Service employees (Timber Managers and Foresters) who select and mark the trees that may be logged, are the subject and focus of this HHE.

Tree-marking teams (usually six or more Foresters) select a starting point in a designated stand of trees and work the area systematically, maintaining a distance between crew members of approximately 10-20 feet. Foresters select trees to cut or save based upon the trunk size and height of the tree and mark these trees with a durable proprietary paint. Foresters apply tree-marking paint on two locations: (1) on the tree trunk at approximately three feet (to mark what will eventually become the log), and (2) just above ground level (at what will eventually be the stump). Marks made by Foresters can vary with the individual and may range from a stripe or blaze mark to a solid circle.

Paints are applied by means of pressurized aerosol spray cans or squirted on the tree with mechanical paint guns. Both paint delivery systems provide an opportunity for worker exposure. The aerosol systems emit a fine mist of paint that can be influenced by wind conditions during the application process, thus potentially blowing the paint mists into or away from the breathing zone of the worker. In contrast, the mechanical paint guns deliver a heavy stream of paint that is less likely to be influenced by the wind; however, the paint stream can splatter back from the tree onto the worker. Furthermore, the paint gun spray tip can clog and must be taken apart periodically and cleaned. Removal of the applicator tip invariably causes work gloves to be contaminated and eventually soaked with paint. Within minutes of starting a painting session, paint aerosols can be seen in the air, and solvent odors can be readily noticed.

Foresters who work on tree-marking crews are expected to wear personal protective equipment (PPE). Each painter is supplied with rubberized rain

gear, hard hat, goggles, leather gloves, leather boots, and dust mask. Weather conditions and worker comfort tend to influence the degree to which workers comply with PPE policies. Workers report that protective gear is least likely to be worn completely during the summer.

Overall, the USFS employs approximately 41,000 workers, 25,000 men (61%) and 16,000 women (39%), in 10 regions and research stations throughout the country. The headquarters for the USFS is in Washington, D.C.

The remainder of this HHE report is divided into the industrial hygiene assessment of current work practices and exposures (Section 1), followed by the epidemiologic study of adverse reproductive outcomes among women in the Forest Service (Section 2). Overall recommendations appear at the end of the epidemiologic report.

SECTION 1
Industrial Hygiene Evaluation

Oconee, Kisatchie, Gifford-Pinchot, and Wallowa-Whitman National Forests

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EVALUATION CRITERIA

To assess the hazards posed by workplace exposures, NIOSH investigators use a variety of environmental evaluation criteria. The primary sources of evaluation criteria for the workplace are: NIOSH criteria documents and recommended exposure limits (RELs),[1] the Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs),[2] and the American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Values (TLVs®).[3] These criteria suggest exposure levels to which most workers may be exposed for a working lifetime without experiencing adverse health effects. However, because of wide variation in individual susceptibility, some workers may experience occupational illness even if exposures are maintained below these limits. The evaluation criteria do not take into account individual hypersensitivity, pre-existing medical conditions, or possible interactions with other work place agents (such as mixtures), medications being taken by the worker, or environmental conditions such as temperature and elevation.

Occupational health criteria are established based on the available scientific information provided by industrial experience, animal or human experimental data, or epidemiologic studies. Differences between the NIOSH RELs, OSHA PELs, and ACGIH TLVs may exist because of different philosophies and interpretations of technical information. It should be noted that RELs and TLVs are guidelines, whereas PELs are standards which are legally enforceable. OSHA PELs are required to take into account the technical and economical feasibility of controlling exposures in various industries where the agents are present. The NIOSH RELs are primarily based upon the prevention of occupational disease without assessing the economic feasibility of the affected industries and as such tend to be conservative. A Court of Appeals decision vacated the OSHA 1989 Air Contaminants Standard in *AFL-CIO v OSHA*, 965F.2d 962 (11th cir., 1992); and OSHA is now enforcing the previous 1971 standards (listed as Transitional Limits in 29 CFR 1910.1000, Table Z-1-A).[2] However, some states which have OSHA-approved State Plans continue to enforce the more protective 1989 limits. NIOSH encourages employers to use the 1989 limits or the RELs, whichever are lower.

Evaluation criteria for chemical substances are usually based on the average personal breathing zone (PBZ) exposure to the airborne substance over an entire 8 to 10 hour workday, expressed as a time-weighted average (TWA). Personal exposures are usually expressed in parts per million (ppm), milligrams per cubic meter (mg/m^3), or micrograms per cubic meter ($\mu g/m^3$). To supplement the 8-hour TWA where there are recognized adverse effects from short-term exposures, some substances have a short-term exposure limit (STEL) for 15-minute peak periods; or a ceiling limit, which is not to be exceeded at any time. Additionally, some chemicals have a "skin" notation to indicate that the substance may be absorbed through direct contact of the material with the skin and mucous membranes.

It is important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these occupational health exposure criteria. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, previous exposures, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other work place exposures, or with medications or personal habits of the worker (such as smoking, etc.) to produce health effects even if the occupational exposures are controlled to the limit set by the evaluation criterion. These combined effects are often not considered by the chemical specific evaluation criteria. Furthermore, many substances are appreciably absorbed by direct contact with the skin and thus potentially increase the overall exposure and biologic response beyond that expected from inhalation alone. Finally, evaluation criteria may change over time as new information on the toxic effects of an agent become available. Because of these reasons, it is prudent for an employer to

maintain worker exposures well below established occupational health criteria.

Petroleum Distillates

The tree-marking paint used by the Forest Service contains petroleum distillates in the form of Stoddard solvent and Aromatic 100. Petroleum distillates (naphtha), also referred to as refined petroleum solvents, is a general term used to describe a class of complex hydrocarbon solvent mixtures.[4] Petroleum naphtha is composed mainly of aliphatic hydrocarbons (as distinguished from coal tar naphtha which is mixture composed primarily of aromatic hydrocarbons).[5,6] Petroleum distillates are further characterized by the boiling range of the mixture; typically, the larger hydrocarbon chain length equates to a higher distillation fraction.[4] Specific names for some typical petroleum distillate mixtures are presented below, in order of increasing temperature of boiling ranges: petroleum ether, rubber solvent, varnish makers' and painters' (VM & P) naphtha, mineral spirits, Stoddard solvent, and kerosene.[4] Boiling ranges of these mixtures overlap, therefore, some of these mixtures contain the same hydrocarbons but in different proportions.

Effects from exposure to refined petroleum solvents are primarily acute, unless significant amounts of substances that have chronic toxicity are present, such as benzene or glycol ethers. Epidemiologic studies have shown that exposure to similarly refined petroleum solvents (i.e., mineral spirits, Stoddard solvent) can cause dry throat, burning or tearing of the eyes, mild headaches, dizziness, central nervous system (CNS) depression, respiratory irritation, and dermatitis.[4]

Petroleum naphtha appears to have weak skin cancer causing potential in laboratory mice.[7] The International Agency for Research on Cancer (IARC) has determined that there is only limited evidence implicating petroleum naphtha as a carcinogen in animals and insufficient evidence associating exposure to petroleum naphtha and the development of cancer in humans.[8] However, depending upon the manufacturing process, petroleum naphtha may sometimes contain varying amounts of aromatic hydrocarbons such as benzene, which has been associated with cancer.[1]

Many petroleum naphtha mixtures used throughout industry contain *n*-hexane or other simple alkanes. Prolonged and repeated exposure to *n*-hexane may damage peripheral nerve tissue and result in muscular weakness and loss of sensation in the extremities.[4] Studies indicate that methyl ethyl ketone (MEK) may potentiate peripheral neuropathy caused by *n*-hexane.[9]

Because naphthas are mixtures of aliphatic hydrocarbons, the evaluation criteria are based upon the mixture composition in relation to the most commonly available products — petroleum ether, rubber solvent, VM & P naphtha, mineral spirits, and Stoddard solvents. The NIOSH REL for all of the petroleum distillate mixtures is 350 mg/m^3 as a full shift TWA exposure, for up to 10 hours per day providing a 40-hour work week is not exceeded. In addition, a ceiling concentration limit (for a 15-minute duration) of 1800 mg/m^3 is recommended by NIOSH. The OSHA PEL for petroleum distillates (naphtha) is 1600 mg/m^3 TWA, while the PEL for Stoddard solvents is 525 mg/m^3. The ACGIH has also established a TLV-TWA (for eight hours) of 1600 mg/m^3 for rubber solvent, 1350 mg/m^3 for VM & P naphtha, and 525 mg/m^3 for Stoddard solvents (and mineral spirits), and a 15-minute STEL of 1800 mg/m^3 for VM & P naphtha.

Methyl Ethyl Ketone

Methyl ethyl ketone (MEK) is a colorless, flammable organic solvent with a characteristic odor similar to acetone and is typically used as a solvent in the surface coating and synthetic resin industries.[10] MEK is absorbed primarily through inhalation and causes irritation of the eyes, mucous membranes, and skin; at high concentrations MEK may cause CNS depression. Short duration inhalation exposure to 100 ppm of MEK was reported to cause slight nose and throat irritation, 200 ppm caused mild eye irritation, and 300 ppm was associated with headaches, throat irritation, as well as an

objectionable odor.[11] Additional studies indicate that MEK by itself does not cause neurologic toxicity of the extremities (peripheral neuropathy), but may potentiate the toxic effects of substances known to cause peripheral neuropathy, such as n-hexane.[6,12,13] Continued or prolonged skin contact with MEK liquid can cause dermatitis.[11]

The National Toxicology Program, an interagency research program, has not found evidence supporting an association between MEK exposure and the development of cancer in humans or experimental animals.[9] NIOSH, OSHA, and ACGIH have proposed the same full-shift inhalation criteria for MEK at 200 ppm averaged over an 8-hour exposure and a STEL of 300 ppm for 15-minutes.

Toluene

Toluene is a colorless, aromatic organic liquid containing a six carbon ring (a benzene ring) with a methyl group (CH_3) substitution. It is a typical solvent found in paints and other coatings, and used as a raw material in the synthesis of organic chemicals, dyes, detergents, and pharmaceuticals. It is also an ingredient of gasoline, ranging from 5% to 22%.[14,15] A previous NIOSH evaluation found that the toluene content of gasoline ranged from 2.4% to 12%, with exposure levels from none detected to 2.1 mg/m^3 (0.56 ppm).[16]

Inhalation and skin absorption are the major occupational routes of entry. Toluene can cause acute irritation of the eyes, respiratory tract, and skin. Since it is a defatting solvent, repeated or prolonged skin contact will remove the natural lipids from the skin which can cause drying, fissuring, and dermatitis.[11,17]

The main effects reported with excessive inhalation exposure to toluene are CNS depression and neurotoxicity.[11] Studies have shown that subjects exposed to 100 ppm of toluene for six hours complained of eye and nose irritation, and in some cases, headache, dizziness, and a feeling of intoxication (narcosis).[18,19,20] No symptoms were noted below 376 mg/m^3 (100 ppm) in these studies.

There are a number of reports of neurological damage due to deliberate sniffing of toluene-based glues resulting in motor weakness, intention tremor, ataxia, as well as cerebellar and cerebral atrophy.[21] Recovery is complete following infrequent episodes; however, permanent impairment may occur after repeated and prolonged glue-sniffing abuse. Exposure to extremely high concentrations of toluene may cause mental confusion, loss of coordination, and unconsciousness.[22,23]

Originally, there was a concern that toluene exposures produced hematopoietic toxicity because of the benzene ring present in the molecular structure of toluene. However, toluene does not produce the severe injury to bone marrow characteristic of benzene exposure as early reports suggested. It is now believed that simultaneous exposure to benzene (present as a contaminant in the toluene) was responsible for the observed toxicity.[10,17]

The NIOSH REL for toluene is 100 ppm for an 8-hour TWA. NIOSH has also set a recommended STEL of 150 ppm for a 15-minute sampling period. The OSHA PEL for toluene is 200 ppm for an 8-hour TWA. The recently adopted ACGIH TLV is 50 ppm for an 8-hour exposure level. This ACGIH TLV carries a skin notation, indicating that cutaneous exposure contributes to the overall absorbed inhalation dose and potential systemic effects.

OCONEE, KISATCHIE, AND GIFFORD-PINCHOT NATIONAL FORESTS

An initial site visit was conducted on September 6, 1995, in the Oconee National Forest outside of Atlanta, Georgia. Several bulk samples of tree-marking paint were collected during this site visit, but there was not an opportunity to collect PBZ air samples. In June and July, 1996, NIOSH industrial hygienists collected air and urine samples for specific chemical exposures during tree-marking operations at the Kisatchie National Forest in central

Louisiana and the Gifford-Pinchot National Forest in southwestern Washington.

Materials and Methods

Seven bulk samples of tree-marking paint were collected during the initial site visit: Nelson red; Southern Coatings blue and green; and Niles yellow, blue, orange, and white. Prior to 1988, only the Nelson brand paints were used. In 1988, the USFS had a transition period during which they changed from Nelson to Southern Coatings and finally to Niles paint. These changes in paint suppliers resulted in a variety of paint brands at each storage location, and therefore, each region used whatever brands were available. All of these bulk samples were analyzed in a NIOSH laboratory for volatile organic compounds (VOCs) by gas chromatography and mass spectrometry (GC/MS) using a 30 meter DB-1 capillary column (splitless mode), and for elements by inductively coupled argon plasma, atomic emission spectroscopy (ICP-AES). (Because the components of these paints are confidential, the exact results will not be presented in this report.) These bulk sample results were used to determine potential exposures from the paints. The following specific compounds were selected for personal exposure assessment based on whether the compounds had any documented association with reproductive health effects and whether a method for assessment existed: toluene, xylene, ethyl benzene, n-butyl acetate, propylene glycol methyl ether acetate (PGMEA), MEK, methyl isobutyl ketone (MIBK), lead, cobalt, and manganese. Standardized urine sampling methods do not exist for some of the VOCs, and MEK cannot be analyzed from a charcoal tube sample; therefore, the air and urine analytes do not correspond exactly.

The personal exposure assessment consisted of collecting full-shift PBZ air samples during tree-marking operations and spot urine samples at the end of the shift in which the PBZ air samples were collected. On the morning of the first day, employees signed voluntary consent forms that acknowledged employee permission for NIOSH to collect and analyze employee urine samples. Employees were individually notified of results of urine sample analysis by letters sent directly from NIOSH to the employees' home address.

Air samples for VOCs were collected on coconut-shell charcoal solid sorbent tubes (100 milligrams [mg]/50 mg) at a flow rate of 100 milliliters per minute (mL/min), and air samples for elements were collected on pre-weighed polyvinyl chloride (PVC) filters at a flow rate of 2 liters per minute (L/min). The VOC samples were analyzed for six compounds (toluene, xylene, ethyl benzene, n-butyl acetate, propylene glycol methyl ether acetate, and methyl isobutyl ketone) and for a total hydrocarbon measurement (based on Stoddard solvent) following NIOSH Methods 1300, 1450, 1501, and 1550 except for the following modifications: (1) the column used was a 30 meter (m) x 0.32 millimeter (mm) fused silica capillary column, coated internally with 1.0 micrometer (µm) of DB-5, and (2) the oven conditions were 80°C for 2 minutes up to 120°C for 0 minutes at a rate of 5°C/minute then up to 270°C for 3 minutes at a rate of 50°C/minute. The elements samples were measured for total weight and analyzed following NIOSH Method 7300.[24]

Thirty-milliliter urine samples were collected from each worker at the end of the shift. These samples were shipped in coolers overnight to the contract laboratory and analyzed for specified VOCs or their metabolites. Analysis for hippuric acid (toluene metabolite), total methylhippuric acids (xylene metabolites), and mandelic acid (ethyl benzene metabolite) was performed by taking a 1.0 milliliters (mL) aliquot of urine, and first acidifying with HCl, saturating with NaCl, and extracting with 4.0 mL of ethyl acetate. Then a 1.0 mL aliquot of that extract is evaporated to dryness and reconstituted to 1.0 mL with reagent grade water. The extract is analyzed by reverse-phase high-performance liquid chromatography (HPLC) with ultraviolet (UV) detection at 220 nanometers (nm). Two levels of spiked control urines, a urine blank, and a reagent blank are monitored with each batch of 20 urine specimens analyzed.

Analysis for o-cresol (also a toluene metabolite) was performed by taking a 4.0 mL aliquot of urine that has been spiked with an internal standard (2-fluorophenol) and acidified with sulfuric acid, and hydrolyzing it at 110°C for 90 minutes. Then the urine is saturated with NaCl, decanted to a second tube and extracted with 5 mL of methylene chloride. The aqueous layer is discarded and the organic layer is washed three times with 3 mL of 5% $NaHCO_3$ solution. Four mLs of the methylene chloride layer is transferred to another tube and evaporated to 0.5 mL. One mL of 0.1 N NaOH is added, the tube is vortexed, centrifuged, and the aqueous layer is transferred to autosampler vials. The extracts are analyzed by reverse-phase HPLC with UV detection at 205 nm, and the instrument is calibrated with five levels of aqueous standards.

Analysis for MEK and MIBK was performed by pipetting a 3.0 mL aliquot of urine into a headspace vial containing 2 grams (g) of NaCl. The vial is mixed, sealed, and heated at 45°C overnight (16 hours). One mL of headspace is analyzed by gas chromatography with a 30 M DB-1 megabore column with photoionization detection. The instrument is calibrated with five levels of aqueous standards.

Observations and Results

After talking with USFS representatives and visiting three of the USFS regions, it was apparent that each region operated somewhat autonomously. The paints that may be used are limited to three brands, one of which can no longer be purchased, but the manner and method of application can vary. Also, the decisions about marking and cutting are made at the regional level, and the type and use of insect repellant as well as the clean-up procedures vary from region to region. Multiple over-the-counter insect repellants, many of which contain diethyltoluamide (DEET), are used. In some regions, workers spray themselves daily with the repellants. Although the USFS does have a standard clean-up policy, the workers in the Kisatchie National Forest used WD40™ to remove paint from their skin.

Even within a region, the method of tree-marking techniques can vary. Some workers spray a minimal amount of paint, and others spray an excess of paint. Some first mark the bottom of the trunk and then at eye level, and others mark the bottom second, bending over into the mist from the first eye-level marking. Although the work is not exhausting, walking through the forests can be tiring and often times quite hot. Workers in the three regions visited all appeared to take sufficient breaks, and water was always carried either by each individual or in a large cooler on the truck.

Kisatchie National Forest, June 25-26, 1996

A team of five workers were sampled during two days of tree-marking. This region uses small cans of paint with spray guns attached to mark the trees. The first day of sampling was in a section of forest being marked for thinning using Niles yellow paint. It was somewhat rainy that day and the air sampling media were ruined by water exposure, therefore only urine samples could be collected. There was no wind, the temperature ranged from 75-80°F, and the relative humidity (RH) ranged from 87-95%.

The second day of sampling was in a section of forest being marked for clear-cutting using Southern Coatings orange paint. Both PBZ air samples and urine samples were collected that day. One of the workers spent most of the second day marking the boundary of the clear-cut area, while the other four marked trees. There was no wind, the temperature ranged from 82-90°F, and the RH ranged from 50-74%. The sampling results are displayed in Tables 1, 2, and 3.

Gifford-Pinchot National Forest, July 30, 1996

A team of five workers were sampled during one day of tree-marking. This region used aerosol spray cans

of Niles blue paint to mark the trees. Some workers used a plastic gun-handle attachment that allowed them to spray the paint with a trigger, while others just used their index finger. During this survey, workers marked trees in a 30-acre section of forest that had been scheduled for heavy thinning. Initially, it was thought that this job would take two days, but it was completed in one. There was no wind, the temperature ranged from 75-80°F, and the RH ranged from 42-61%. PBZ air samples were collected and analyzed for VOCs and elements. At the end of the shift, a urine sample was collected from each worker. The sampling results are displayed in Tables 4, 5, and 6.

Discussion and Conclusions

The results suggest that paint exposures during tree-marking operations are quite low. Except for low concentrations of a total hydrocarbon measurement and xylene (Gifford-Pinchot forest only), inhalation exposures to VOCs were not detected. This is not surprising since the work is outside. The results are similarly low or not detected for inhalation exposures to elements. The urine sampling results suggest that internal doses received from paint exposure are also quite low or not detected. In both locations, the hippuric acid (a toluene metabolite) concentrations were all well below the 1.5 grams per gram of creatinine (g/g Cr) which is normally found in urine. The o-cresol metabolite is a more specific indicator of toluene exposure than hippuric acid and is normally found in unexposed populations at concentrations up to 0.1 milligrams per liter (mg/L). This metabolite was not detected in workers from the Kisatchie region, but was detected in workers from the Gifford-Pinchot region. Nevertheless, the o-cresol concentrations were just over the analytical limit of detection (LOD) and the reference range of <0.1 mg/L, which suggests that the internal dose to toluene was low. Also, a few workers from each region had detectable concentrations of MEK in their urine. The concentrations were all an order of magnitude below the ACGIH Biological Exposure Index (BEI™) of 2 mg/L, but they were all over the reference range of <0.1 mg/L for unexposed populations.

Overall, the PBZ and urine samples suggest a very low-level of VOC and element exposure from tree-marking operations. Taken individually, most of the specific VOCs or elements are so low that they cannot be detected. These sampling results indicate that the only individual compounds that a tree-marker might be exposed to in detectable concentrations during these surveys and that have a slight, but potential, association to reproductive health effects are MEK, toluene, and manganese. All the measured exposures were well below any current occupational exposure limits, but the relevant occupational exposure limits are not based on reproductive effects.

WALLOWA-WHITMAN NATIONAL FOREST

On July 14-17, 1997, an industrial hygiene survey was conducted during timber-marking operations on the Wallowa-Whitman National Forest at the Sumpter timber sale approximately 22 miles west of Baker City, Oregon. During this site visit, NIOSH industrial hygienists collected PBZ air samples for solvents, metals, and dusts and conducted biological monitoring by collecting pre- and post-shift urine samples. This specific site visit was requested by the Foresters of the Wallowa-Whitman National Forest due to acute health effects including headache, nausea, vomiting, dizziness, and CNS symptoms.

Materials and Methods

Eight Foresters participated in this survey. On the morning of the first day, voluntary consent forms were given to each employee to sign. The consent form acknowledged employee permission for NIOSH to collect and analyze employee urine samples. Employees were individually notified of results of urine sample analysis by letters sent directly from NIOSH to the employees' home address.

Full-shift PBZ air samples were collected for hydrocarbons, elements (metals), and total

particulate. Sampling trains were calibrated using a primary standard at Baker City, Oregon (elevation 3328 feet above sea level). Because of barometric pressure differences between the elevation where the sampling trains were calibrated and the location where samples were collected (elevation 4467 feet above sea level), an air density correction factor was calculated and used in determining air sample volumes.

Employees were asked to wear two, and on one day three, air sampling trains. One sampling train collected metals and total dust on a filter cassette, another sampling train collected hydrocarbons for quantitative analysis using an activated charcoal tube, and a third sampling train, a thermal desorption tube, collected VOCs for qualitative analysis. All sampling media were attached to the employee's lapels and were checked several times during the morning and afternoon periods of work. NIOSH industrial hygienists accompanied each team of four employees into the field each day to observe employee work practices and to perform flow checks on the air sampling trains.

A total of 31 PBZ samples were collected for quantitative analysis for hydrocarbons, metals, and total particulate. Eight thermal desorption PBZ samples (two samples each day) were collected from two different employees each day.

VOCs were collected on coconut-shell charcoal solid sorbent tubes (100 mg/50 mg) using SKC® pocket pumps connected in-line using Tygon® tubing. The sampling trains were calibrated to flow rate of 100 mL/min. Elements (metals) and total dusts were collected using pre-weighed 37 mm polyvinyl chloride (PVC) filter cassettes connected in-line with Tygon® tubing to Gilian® personal sample pumps. These sampling trains were calibrated to a flow rate of 2 L/min. To characterize VOC emissions from tree-marking paint, PBZ air samples were collected on thermal desorption tubes using SKC® pocket pumps at 50 cubic centimers per minute (cc/min). These samples were analyzed by a NIOSH laboratory using GC/MS with a Perkin-Elmer ATD 400 thermal desorption system. Once the qualitative analytical results were obtained, a NIOSH contract laboratory was instructed to quantitatively analyze the charcoal tube samples for total hydrocarbons (based on Stoddard solvent), toluene, methyl isobutyl ketone, and total trimethyl benzene. NIOSH Methods 1300, 1501, and 1550 were used with some modifications: (1) the column used was a 30 m x 0.32 mm fused silica capillary column, coated internally with 0.5 μm of DB-wax, and (2) the oven conditions were 40°C for 7 minutes up to 60°C for 10 minutes at a rate of 5°C/minute then up to 180°C for 3 minutes at a rate of 20°C/minute.

For particulates and metals, gravimetric analysis was first performed by the laboratory to determine total filter weight differences. Inductively coupled argon plasma, atomic emission spectroscopy (ICAP-AES) was then used to analyze the filters for elements (metals) following NIOSH Analytical Method 7300.[24]

Bulk samples of Niles and Nelson paint were analyzed in-house for elements. Samples of approximately 20 cc of Niles and Nelson paint were collected during the field survey. Air sampling during simulated tree-marking was performed at the NIOSH laboratory. Samples of 3 cc of each Niles and Nelson marking paints were applied outdoors to equal sized pieces of ponderosa pine bark. Air samples were collected approximately four inches above each piece of bark. The air samples were used to qualitatively identify and compare any differences in quantity and type of VOCs present in the paint volatiles between the two types of paint.

Prior to work on Monday morning, and then at the end of each day's work, employees were provided with specimen cups to provide urine samples. Urine was analyzed for the presence of solvents or solvent metabolites suspected to be present in marking paint. Analysis was performed for a solvent panel which included toluene, ethylbenzene, xylene, MEK, and MIBK. The laboratory was requested to hold analysis on the pre-shift samples until all post-shift samples were analyzed. If any of the post-shift samples had solvents or solvent metabolites present above the LOD, the laboratory was instructed to

analyze the pre-shift samples. In the event all post-shift samples were found to be below the LOD for metabolites or individual solvents, pre-shift samples were not analyzed. After collection, urine was transferred to the brim of a labeled specimen vial (to restrict headspace and to prevent any loss of analytes from volatilization), immediately refrigerated in coolers, and shipped overnight to a contract laboratory. Analysis for hippuric acid (toluene metabolite), total methylhippuric acids (xylene metabolites), and mandelic acid (ethyl benzene metabolite) was performed by taking a 1.0 mL aliquot of urine, and first acidifying with HCl, saturating with NaCl, and extracting with 4.0 mL of ethyl acetate. Then a 1.0 mL aliquot of the extract was evaporated to dryness and reconstituted to 1.0 mL with reagent grade water. The extract is analyzed by reverse-phase HPLC with UV detection at 220 nm.

Analysis for o-cresol (also a toluene metabolite) was performed by taking a 4.0 mL aliquot of urine that was spiked with an internal standard (2-fluorophenol) and acidified with sulfuric acid, and hydrolyzing it at 110°C for 90 minutes. Then the urine was saturated with NaCl, decanted to a second tube and extracted with 5 mL of methylene chloride. The aqueous layer was discarded and the organic layer is washed three times with 3 mL of 5% $NaHCO_3$ solution. Four mLs of the methylene chloride layer is transferred to another tube and evaporated to 0.5 mL. One mL of 0.1 N NaOH is added, the tube vortexed, centrifuged, and the aqueous layer transferred to autosampler vials. The extracts are analyzed by reverse-phase HPLC with UV detection at 205 nm, and the instrument is calibrated with five levels of aqueous standards.

Analysis for MEK and MIBK was performed by pipetting a 3.0 mL aliquot of urine into a headspace vial containing 2 gram of NaCl. The vial was mixed, sealed, and heated at 45°C overnight (16 hours). One mL of headspace was analyzed by gas chromatography with a 30 M DB-1 megabore column with photoionization detection. The instrument is calibrated with five levels of aqueous standards. Split samples and controls (urine samples from the two NIOSH investigators collected on the morning of the first day) were shipped with the samples and labeled as employee samples.

Observations

Two teams of four employees marked timber over four consecutive days at the Sumpter timber sale. One employee missed one day of work on the second day of the survey when he was ill. Timber consisted principally of an 80 year-old naturally reforested stand of Ponderosa pine. Niles brand tree-marking paint was used for the first three days, and Nelson brand paint was used on the final day of the survey. Employees reported to the NIOSH industrial hygienists that they experienced more health symptoms (e.g., headache, nausea, vomiting, dizziness, and upper respiratory irritation) when using Niles paint compared to using another brand such as Nelson tree-marking paint.

Weather during the survey was clear and sunny with the exception of a short rain shower at the end of final day of the survey. Temperatures at the site ranged from 60-61°F in the morning to 90°F in the afternoons. RH was measured in a range of 52-53% in the mornings to a low of 13% on one afternoon. Wind at the survey site varied. In the early morning, wind was not detectable. Breezes of 1-2 miles per hour (mph) were measured each day during mid-morning periods and wind up to 7 mph (the highest measured) occurred on a ridge of the timber sale during the second day of the survey. Overall, the timber was not dense; however, sections of relatively denser timber were marked during the third day of the survey.

NIOSH industrial hygienists noted that timber-marking techniques were different between Foresters. Some employees spray a minimal amount of paint, while others apply more paint to each tree. For example, some employees consistently used three squeezes of the paint gun handle to mark a tree (one stump dot and a breast blaze on either side of the tree). Other Foresters used four squeezes to mark each tree (an X or a Y mark near the base and a breast blaze on either side of the tree). Some

employees first apply the stump dot, then mark the breast blaze, while others apply the breast blaze first then the stump dot. An appreciable amount of paint splatter occurs in the form of paint droplets and mists which are formed when the stream of paint contacts the irregular surface of the bark. This was photographed by NIOSH industrial hygienists. Depending how an employee chooses to mark an area of timber and the direction of wind, if any, Foresters may end up moving towards or away from paint mist. By the end of the week, some employees clothing, specifically their boots and pant legs, were clearly discolored due to overspray from paint mist or drips from the paint gun.

It was reported to NIOSH that in some circumstances paint mist clouds were visible in the forests during marking operations in thick timber and calm winds. NIOSH did not observe this during marking operations at the Sumpter site. However, when Foresters entered a stand of timber and began marking, the smell of solvent vapor was immediately noticeable throughout the area. Within an hour of beginning work on the first day of the survey, several Foresters reported symptoms including nausea, numbness of the lips, dizziness, and loss of coordination. Headache, eye irritation, and increased heart rate were also reported. The same symptoms were reported by some, but not by all employees on various days of the survey. Some employees reported that the morning after they mark timber they experience a headache upon waking, others reported a solvent-like taste in their mouths.

The topography of this survey area was predominantly level and because of this, the work was not as exhausting as might be the case in much steeper terrain. Marking timber appeared to be tedious work. Foresters were required to negotiate uneven and irregular terrain, avoid tripping over deadfall, while frequently looking up to judge the scale of the surrounding timber. Foresters are laden with marking paint, often carrying up to six replacement quarts and a quart can of paint attached to their marking gun. Temperatures during eastern Oregon summers can become quite hot (>90° F), as was the case during this survey. Employees took rest breaks when needed and had access to water which they carried with them and was available at the crew truck.

Results

Hydrocarbons

Thirty-one PBZ air samples collected for hydrocarbons indicate total hydrocarbon concentrations ranged from trace [an amount between the limit LOD and the limit of quantitation (LOQ)] to 5.5 mg/m^3 (Table 7). Air samples collected using thermal desorption tubes included more than 20 chemicals including naphtha compounds (C_9-C_{12} aliphatic and aromatic hydrocarbons) hexanal, toluene, methyl isobutyl ketone, pentanal, xylene, methyl ethyl ketone, phthalic anhydride, and DEET [an insect repellent]).

NIOSH provided preliminary air sampling results to the Forest Service in a letter dated October 22, 1997 (Appendix A). Foresters on the Wallowa-Whitman National Forest became concerned that toluene was detected in some of the air samples because, according to the Forest Service, toluene is a prohibited chemical in tree-marking paints and the Forest Service restricts the addition of toluene as an ingredient in tree-marking paints. In 7 of the 31 (22.6%) samples, toluene was not detected to the LOD which was 0.001 mg/sample. For 17 of the 31 (54.8%) samples, toluene was found at a trace concentrations. Seven of the 31 (22.6%) air samples contained toluene above the LOQ which was reported at 0.0033 mg/sample. In samples where toluene was detected, it ranged from 0.14 mg/m^3 to 0.33 mg/m^3. There was not an association between increased total hydrocarbon concentrations in air samples and increased toluene concentrations.

Total trimethyl benzene (TMB) concentrations ranged from not detected (ND) to 0.55 mg/m^3. TMB concentrations were determined to be roughly one tenth of the total hydrocarbon concentrations for 18 of 31 (58%) samples. Methyl isobutyl ketone (MIBK) was either ND or detected at trace

concentrations for all but one sample where MIBK concentration was determined at 0.13 mg/m^3. This sample also had the highest concentrations of both total hydrocarbons and TMB.

There were no apparent differences in concentrations of total hydrocarbons (measured as Stoddard solvent) between PBZ samples when comparing Niles and Nelson brand paints. For example, six of the eight (75%) PBZ samples collected when Nelson paint was used had total hydrocarbon concentrations that were within the range of concentrations detected when Niles paint was used. However, there was an increase in concentration of both toluene and TMB, comparing any one of the three days when Niles paint was applied to the day when Nelson paint was used. Toluene was detected in 7 of the 31 (22.6%) air samples on the three days when Niles paint was used. Toluene was either ND or detected in trace concentrations on the one day when Nelson paint was used. TMB was always detected above the LOD when Niles paint was used (concentrations ranged from 0.12 mg/m^3 to 0.55mg/m^3) and with the exception of one PBZ sample collected on the first day of the survey (0.14 mg/m^3), TMB was either ND or present in trace concentrations when Nelson paint was used.

PBZ samples on Foresters did not show a corresponding increase in total hydrocarbon concentrations and the number of cans of paint used for the day. However, for PBZ samples where toluene was detected above trace concentrations, there appeared to be an increasing trend between airborne concentrations of toluene and the numbers of cans of paint used on a particular day.

There were differences in the kinds of hydrocarbons present in PBZ samples and the simulated tree-marking air samples comparing Niles and Nelson paint (when paint was applied to pieces of pine bark). Comparison of chromatograms of two air samples indicate considerably lower amounts of C_9-C_{12} aliphatic hydrocarbons in the air samples of the Nelson paint. Toluene was present in both types of paint but in lower concentration (based on area and peak height of the chromatograms) in Nelson compared to Niles paint. Trimethyl benzene was in significantly lower concentrations in the Nelson paint. MEK was found in Niles paint but was absent in the air sample of the Nelson paint.

Total Particulates (Dusts)

Total particulate concentrations were low, ranging from 0.03 mg/m^3 to 5.21 mg/m^3 (Table 8). The majority of PBZ samples (93.5%) were less than 1 mg/m^3. Concentrations were all below the OSHA PEL 15 mg/m^3 for total dusts and the ACGIH TLV of 10 mg/m^3 for particulates not otherwise regulated. NIOSH does not have a criteria for total or nuisance dusts.

Elements (Metals)

Toxic metals, including cadmium, manganese, lead, and chromium were found on some air samples, but these metals were found in trace concentrations that are well below any evaluation criteria or consensus standards (Table 8). Beryllium, a toxic metal, was found on one PBZ air sample and was above the LOD, but the airborne concentration was below the OSHA and NIOSH criteria for occupational exposures.

Biological Monitoring

Methyl ethyl ketone was the only solvent (or metabolite of solvent) detected in any of the urine samples for any of the employees who participated in the investigation (Table 9). Concentrations of MEK in the samples ranged from ND [or less than (<) 0.10 mg/L] to 0.77 mg/L. The ACGIH BEI for MEK is 2 mg/L. The amounts of MEK found in all the urine samples were all below the BEI recommended by ACGIH. Corrected concentrations of hippuric acid (a non-specific metabolite of toluene) were all well below 1.5 grams of hippuric acid per gram of creatinine (g/g Cr) which can be a background level due to metabolism of certain acidic foods. The o-cresol metabolite is a more specific indicator of toluene exposure than hippuric acid and is normally found in unexposed populations at concentrations up

to 0.1 mg/L. This metabolite was ND (to the LOD) in employees marking timber on the Wallowa-Whitman National Forest. MEK was found in four of the eight pre-shift urine samples which were collected on July 14, 1997. The reasons for this finding are unclear. All employees were asked prior to submitting the Monday morning urine sample if anyone had used solvents or enamel paints over the weekend. While one employee reported using a latex house paint, no employees reported using solvents or enamel type paints. The presence of small amounts of MEK found in these pre-shift urine samples suggests recent exposure prior to the beginning of work on Monday July 14, 1997. One explanation for this may be exposure to butyl alcohol because butyl alcohol is converted to MEK in the body. Butyl alcohol is also present in polishes, cleaning materials, paint solvents, some perfumes, and lacquer solvents. Another explanation may be exposure to residues of tree-marking paint during the drive in to work. This exposure might be explained by the presence of paint residues on work clothing used for painting the previous week, or uncured paint residues on automobile upholstery fabric.

Discussion and Conclusions

By the nature of their work as painters, Foresters have inhalation exposures to mixed organic solvents and some metals. They also have exposures to particulates, most likely from soils disturbed while working in forested areas. Solvent exposures include the C_9-C_{12} aliphatic and several aromatic hydrocarbons which are present in paint formulations. The Material Safety Data Sheets (MSDS) for the Niles tree-marking paints list only two ingredients, Stoddard solvent and Aromatic 100, which are both solvent blends containing straight and branched chain paraffins, napthenes, and aromatic hydrocarbons. Toluene, xylene, decane, trimethyl benzene, methyl iso-butyl ketone, and MEK are known to be present in the paint formulation based on the results of industrial hygiene air sampling. Toluene and xylene are likely to be present as aromatic fractions of both the Stoddard solvent and the Aromatic 100.

Symptoms of headache, dizziness, nausea, upper respiratory irritation, and loss of coordination were reported by employees during tree-marking operations in the Wallowa-Whitman National Forest. These types of CNS symptoms are consistent with exposures to several of the solvents identified by the PBZ samples. However, for any individual solvent alone (i.e., toluene, MIBK, or TMB) the concentrations did not exceed any occupational exposure limits enforced by OSHA, recommended by NIOSH, or adopted by ACGIH. (The criteria for these chemicals are listed at the bottom of Table 7.) The exposures measured in this study were also below criteria for mixtures with additive effects. However, health effects from most mixture exposures, including multiple solvent exposures, are not yet well understood. One explanation for the symptoms reported by the workers may be that a synergistic effect (i.e., the combined effect of the mixed solvent exposures is greater than the sum of the exposures to individual solvents alone, or to a solvent mixture for which additive effects would apply) is responsible for the reports of CNS symptoms which employees described when they used tree-marking paint. Symptoms reported by this group of workers could also be aggravated by the environmental conditions at the work site (temperatures in excess of 90°F, and elevations greater than 4400 feet).

Engineering controls to reduce exposures are infeasible due to the mobile nature of the work and because the work occurs outdoors. Air purifying half-mask respirators are not recommended as a feasible control option principally because respirators could place additional stressors on employees, and obtaining an adequate face seal may also be difficult on hot days particularly when workers are perspiring heavily.

The most practical alternative appears to be product substitution. Substitution of a suitable paint meeting the performance needs of the Forest Service that does not result in exposures which cause the acute CNS effects reported by Foresters is suggested. High solids, low solvent paints should be investigated for substitution and use. High

performance water-based paint systems (e.g. acrylic latex enamel) are available and should be strongly considered, but Forest Service paint performance criteria may need to be reevaluated and some performance criteria may need to be relaxed. It is important to note that while water-based paint systems still contain solvents, exposures to aromatic and aliphatic solvents would be expected to be significantly lower due to formulation differences and reduced aromatic and aliphatic solvent content. Water-based paint formulations that do not contain formaldehyde or ethylene glycol, should be selected. In addition, new paint formulations should minimize unreacted monomer content in any polymers used, and minimize the ammonia content.

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Table 1
Results of Personal Breathing Zone (PBZ) Samples Analyzed for Volatile Organic Compounds
USFS, Kisatchie National Forest, June 25-26, 1996
HETA 93-1035

Worker	Date of sampling	Flow Rate (mL/min)	Sample Volume (L)	Analyte Concentration						
				Total Hydrocarbon (based on Stoddard solvent) (mg/m^3)	Toluene (ppm)	Xylene (ppm)	Ethyl Benzene (ppm)	n-Butyl Acetate (ppm)	PGMEA (ppm)	MIBK (ppm)
Forester 1	6/26/96	100	28.9	1.3	ND	trace	ND	ND	ND	ND
Forester 2	6/26/96	100	28.2	2.9	ND	trace	ND	ND	ND	ND
Forester 3	6/26/96	100	28.3	1.0	ND	ND	ND	ND	ND	ND
Forester 4	6/26/96	100	29.1	2.3	ND	trace	ND	ND	ND	ND
Forester 5	6/26/96	100	29.0	5.9	trace	trace	ND	ND	ND	ND
NIOSH REL				350	100	100	100	150	none	50
OSHA PEL				500	200	100	100	150	none	100
ACGIH™ TLV™				100	50	100	100	150 (proposed change to 20)	none	200

NIOSH REL = National Institute for Occupational Safety and Health recommended exposure limit
OSHA PEL = Occupational Safety and Health Administration permissible exposure limit
ACGIH™ TLV™ = American Conference of Governmental Hygienists Threshold Limit Value
mL/min = milliliters per minute
mg/m^3 = milligrams per cubic meter
ppm = parts per million
ND = below minimum detectable concentration of 0.05 ppm
PGMEA = propylene glycol methyl ether acetate
trace = below minimum quantifiable concentration of 0.17 ppm
MIBK = methyl isobutyl ketone

Table 2
Results of Urine Sample Analysis
USFS, Kisatchie National Forest, June 25-26, 1996
HETA 93-1035

Worker	Date of sampling	Sample Volume (mL)	Analyte Concentration					
			MEK (mg/L)	MIBK (mg/L)	(toluene metabolites)		(xylene metabolite) Total Methylhippuric Acids (g/g Cr)	(ethyl benzene metabolite) Mandelic Acid (g/g Cr)
					Hippuric Acid† (g/g Cr)	o-Cresol (g/g Cr)		
Forester 1	6/25/96	30	ND	ND	0.69	ND	ND	ND
Forester 2		30	0.19	ND	0.23	ND	ND	ND
Forester 3*		30	ND	ND	0.84	ND	ND	ND
Forester 4		30	ND	ND	0.26	ND	ND	ND
Forester 5*		30	ND	ND	0.42	ND	ND	ND
Forester 1	6/26/96	30	ND	ND	0.73	ND	ND	ND
Forester 2		30	0.24	ND	0.39	ND	ND	ND
Forester 3*		30	ND	ND	0.27	ND	ND	ND
Forester 4		30	ND	ND	0.20	ND	ND	ND
Forester 5		30	0.15	ND	0.70	ND	ND	ND
Limit of Detection (LOD)			0.1 mg/L	0.1 mg/L	0.05 g/L	0.1 mg/L	0.5 g/L	0.05 g/L
ACGIH™ BEI™ ‡			2 mg/L	2 mg/L	2.5 g/g Cr**	none	1.5 g/g Cr	1.5 g/g Cr

* Creatinine concentration not between 0.5-3.0 g/L and therefore not reliable. Creatinine adjusted measurements for these samples may not be accurate.
† Hippuric acid is normally present in urine from diet at concentrations up to 1.5 g/g Cr.
‡ American Conference of Governmental Industrial Hygienists Biological Exposure Index
** The BEI of 2.5 g/g Cr corresponds to the old TLV™ of 100 ppm. Now that the TLV™ has been lowered to 50 ppm, the BEI™ is intended to be changed, but no numeric value has been listed.
ND = none detected, quantities may be present but are below the analytical limit of detection
mL = milliliters mg/L = milligrams per liter g/g Cr = grams per gram creatinine g/L = grams per liter

Table 3
Results of Personal Breathing Zone (PBZ) Samples Analyzed for Elements
USFS, Kisatchie National Forest, June 25-26, 1996
HETA 93-1035

Worker	Date of sampling	Flow Rate (L/min)	Sample Volume (L)	Analyte Concentration (mg/m^3)				
				Total Mass	Manganese	Sodium	Analytes detected in trace quantities	Analytes sampled for but not detected
Forester 1	6/26/96	2	578	0.13	trace	trace	barium calcium copper iron magnesium molybdenum phosphorous lead tellurium zinc zirconium	silver aluminum arsenic beryllium cadmium cobalt chromium lithium nickel platinum selenium thallium titanium vanadium yttrium
Forester 2	6/26/96	2	564	0.18	0.00008	trace		
Forester 3	6/26/96	2	566	0.08	trace	trace		
Forester 4	6/26/96	2	582	0.19	0.00008	0.02		
Forester 5	6/26/96	2	580	0.26	0.0001	trace		
MDC				0.03	0.000017	0.003	0.0052	0.0052
MQC				-	0.00006	0.013	0.013	0.013
NIOSH REL				none	1 STEL 3	none		
OSHA PEL				15	C 5	none		
ACGIH™ TLV™				10	0.2	none		

L/min = liters per minute mg/m^3 = 00milligrams per cubic meter $\mu g/m^3$ = micrograms per cubic meter
MDC = minimum detectable concentration MQC = minimum quantifiable concentration trace = between the MDC and MQC
NIOSH REL = National Institute for Occupational Safety and Health recommended exposure limit
OSHA PEL = Occupational Safety and Health Administration permissible exposure limit
ACGIH™ TLV™ = American Conference of Governmental Hygienists Threshold Limit Value

Table 4
Results of Personal Breathing Zone (PBZ) Samples Analyzed for Volatile Organic Compounds
USFS, Gifford-Pinchot National Forest, July 30, 1996
HETA 93-1035

Worker	Date of sampling	Flow Rate (mL/min)	Sample Volume (L)	Analyte Concentration						
				Total Hydrocarbon (based on Stoddard solvent) (mg/m^3)	Toluene (ppm)	Xylene (ppm)	Ethyl Benzene (ppm)	n-Butyl Acetate (ppm)	PGMEA (ppm)	MIBK (ppm)
Forester 1	7/30/96	100	31.5	6.3	trace	0.12	ND	ND	trace	ND
Forester 2	7/30/96	100	31.2	3.1	trace	0.07	ND	ND	trace	ND
Forester 3	7/30/96	100	31.0	4.5	trace	0.10	ND	ND	trace	ND
Forester 4	7/30/96	100	31.3	3.5	trace	0.08	ND	ND	trace	ND
Forester 5	7/30/96	100	31.4	4.5	trace	0.09	ND	ND	trace	ND
NIOSH REL				350	100	100	100	150	none	50
OSHA PEL				500	200	100	100	150	none	100
ACGIH™ TLV™				100	50	100	100	150 (proposed change to 20)	none	200

NIOSH REL = National Institute for Occupational Safety and Health recommended exposure limit
OSHA PEL = Occupational Safety and Health Administration permissible exposure limit
ACGIH™ TLV™ = American Conference of Governmental Hygienists Threshold Limit Value
ND = below minimum detectable concentration of 0.008 ppm
trace = below minimum quantifiable concentration of 0.03 ppm
mL/min = milliliters per minute
mg/m^3 - milligrams per cubic meter
ppm = parts per million
PGMEA = propylene glycol methyl ether acetate
MIBK = methyl isobutyl ketone

Table 5
Results of Urine Sample Analysis
USFS, Gifford-Pinchot National Forest, July 30, 1996
HETA 93-1035

Worker	Date of sampling	Sample Volume (mL)	Analyte Concentration					
			MEK (mg/L)	MIBK (mg/L)	(toluene metabolites)		(xylene metabolites) Total Methylhippuric Acids (g/g Cr)	(ethyl benzene metabolite) Mandelic Acid (g/g Cr)
					Hippuric Acid† (g/g Cr)	o-Cresol (g/g Cr)		
Forester 1	7/30/96	30	0.31	ND	0.31	0.1	ND	ND
Forester 2		30	ND	ND	0.18	ND	ND	ND
Forester 3		30	0.12	ND	0.37	0.2	ND	ND
Forester 4		30	ND	ND	0.31	0.1	ND	ND
Forester 5		30	0.17	ND	0.20	0.2	ND	ND
Limit of Detection (LOD)			0.1 mg/L	0.1 mg/L	0.05 g/L	0.1 mg/L	0.1 g/L	0.05 g/L
ACGIH™ BEI™ ‡			2 mg/L	2 mg/L	2.5 g/g Cr**	none	1.5 g/g Cr	1.5 g/g Cr

† Hippuric acid is normally present in urine from diet at concentrations up to 1.5 g/g Cr.
‡ American Conference of Governmental Industrial Hygienists Biological Exposure Index
** The BEI of 2.5 g/g Cr corresponds to the old TLV™ of 100 ppm. Now that the TLV™ has been lowered to 50 ppm, the BEI™ is intended to be changed, but no numeric value has been listed.
ND = none detected, quantities may be present but are below the analytical limit of detection
mL = milliliters
mg/L = milligrams per liter
g/g Cr = grams per gram creatinine
g/L = grams per liter

Table 6
Results of Personal Breathing Zone (PBZ) Samples Analyzed for Elements.
USFS, Gifford-Pinchot National Forest, July 30, 1996
HETA 93-1035

Worker	Date of sampling	Flow Rate (L/min)	Sample Volume (L)	Analyte Concentration (mg/m^3)						
				Total Mass	Manganese	Aluminum	Iron	Titanium	Analytes detected in trace quantities	Analytes sampled for but not detected
Forester 1	7/30/96	2	630	0.17	0.00008	trace	0.005	trace	barium calcium lithium magnesium molybdenum lead sodium vanadium zirconium	silver arsenic beryllium cadmium cobalt chromium copper nickel phosphorous platinum selenium tellurium thallium yttrium zinc
Forester 2	7/30/96	2	624	0.34	0.0001	trace	trace	trace		
Forester 3	7/30/96	2	604.5	0.28	0.0001	trace	trace	trace		
Forester 4	7/30/96	2	594.7	0.32	0.0002	0.006	0.005	trace		
Forester 5	7/30/96	2	612.3	2	0.0002	0.008	0.005	0.0008		
MDC				0.03	0.00002	0.002	0.001	0.0003	0.005	0.005
MQC				-	0.00006	0.006	0.004	0.0007	0.012	0.012
NIOSH REL				none	1 STEL 3	10	5	none		
OSHA PEL				15	C 5	15	10	none		
ACGIH™ TLV™				1	0.2	10	1	none		

L/min = liters per minute MQC = minimum quantifiable concentration trace = between the MDC and MQC
mg/m^3 = milligrams per cubic meter $\mu g/m^3$ = micrograms per cubic meter MDC = minimum detectable concentration
NIOSH REL = National Institute for Occupational Safety and Health recommended exposure limit
OSHA PEL = Occupational Safety and Health Administration permissible exposure limit
ACGIH™ TLV™ = American Conference of Governmental Hygienists Threshold Limit Value

Table 7
Results of Personal Breathing Zone (PBZ) Samples Analyzed for Volatile Organic Compounds
USFS, Wallowa-Whitman National Forest, July 14-17, 1997
HETA 93-1035

Worker	Date of sampling	Flow Rate (mL/min)	Sample Volume (L)	Analyte Concentration						
				Total Hydrocarbons (based on Stoddard solvent) (mg/m^3)	Toluene ($mg/m^{3)}$	MIBK (mg/m^3)	Total TMB (mg/m^3)	# cans of paint applied	# trees painted	Type of paint gun
Forester A	7/14/97	100	34	Trace	ND	ND	0.14	7.5	975	Nelspot
"	7/15/97	100	29	5.5	Trace	0.13	0.55	7	820	"
"	7/16/97	100	36	2.3	Trace	Trace	0.22	8.5	1052	"
"	7/17/97	100	37	4.6	Trace	Trace	0.14	10	1325	"
Forester B	7/14/97 (no sample 7/15/97)	100	34	2.6	Trace	Trace	0.28	8.75	853	Trecoder (a.m.) Nelspot (p.m)
"	7/16/97	100	33	2.7	0.33	Trace	0.29	10.5	1082	Nelspot
"	7/17/97	100	34	2.7	Trace	Trace	Trace	115	1060	Nelspot
Forester C	7/14/97	100	33	3.3	0.24	Trace	0.36	12.5	940	Nelspot
"	7/15/97	100	37	2.2	Trace	Trace	0.25	9.5	780	Nelspot
"	7/16/97	100	32	2.8	Trace	Trace	0.29	8.5	1052	Nelspot
"	7/17/97	100	33	2.4	Trace	ND	Trace	10.5	1070	Nelspot
Forester D	7/14/97	100	26	4.2	0.15	Trace	0.42	9	1075	Trecoder
"	7/15/97	100	37	1.6	Trace	Trace	0.17	9.5	940	Trecoder
"	7/16/97	100	34	2.9	Trace	Trace	0.32	10.5	1010	Trecoder
"	7/17/97	100	35	Trace	ND	ND	Trace	9	940	Trecoder
Forester E	7/14/97	100	31	2.2	0.21	Trace	0.32	12	1085	Trecoder
"	7/15/97	100	32	Trace	Trace	Trace	0.16	12	1214	Trecoder

Table 7 (Continued)

Worker	Date of sampling	Flow Rate (mL/min)	Sample Volume (L)	Analyte Concentration						
				Total Hydrocarbons (based on Stoddard solvent) (mg/m^3)	Toluene ($mg/m^{3)}$	MIBK (mg/m^3)	Total TMB (mg/m^3)	# cans of paint applied	# trees painted	Type of paint gun
" "	7/16/97	100	38	Trace	Trace	ND	0.12	8	904	Trecoder
" "	7/17/97	100	30	Trace	ND	ND	ND	12	1370	Trecoder
Forester F	7/14/97	100	30	2.0	Trace	Trace	0.19	8	600	Trecoder
" "	7/15/97	100	31	ND	Trace	ND	0.12	8	800	Trecoder
" "	7/16/97	100	36	2.2	Trace	Trace	0.23	9	700	Trecoder
" "	7/17/97	100	32	Trace	ND	ND	Trace	7	600	Trecoder
Forester G	7/14/97	100	32	1.9	Trace	Trace	0.21	6	816	Nelspot
" "	7/15/97	100	32	Trace	0.14	Trace	0.17	6	797	Nelspot
" "	7/16/97	100	37	1.6	Trace	Trace	0.16	6.5	764	Nelspot
" "	7/17/97	100	32	Trace	ND	ND	Trace	8.5	983	Nelspot
Forester H	7/14/97	100	31	2.1	Trace	Trace	0.19	6	570	Nelspot
" "	7/15/97	100	33	1.7	0.14	ND	0.13	6	700	Nelspot
" "	7/16/97	100	37	2.1	0.16	Trace	0.2	7	800	Nelspot
" "	7/17/97	100	14	Trace	ND	ND	ND	5	650	Nelspot
NIOSH REL				350	375	205	125			
OSHA PEL				525	375	205	125			
ACGIH™ TLV™				100	50	205	123			

NIOSH REL = National Institute for Occupational Safety and Health recommended exposure limit
OSHA PEL = Occupational Safety and Health Administration permissible exposure limit
ACGIH™ TLV™ = American Conference of Governmental Hygienists Threshold Limit Value
ND = not detected, below minimum detectable concentration (MDC) of 0.61 mg/m^3 (total hydrocarbons)
mL/min = milliliters per minute mg/m^3 = milligrams per cubic meter ppm = parts per million
TMB = trimethyl benzene 0.03 mg/m^3 (toluene, MIBK, total trimethyl benzene)
trace = concentration between limit of detection and limit of quantitation MIBK = methyl isobutyl ketone

Table 8
Results of Personal Breathing Zone (PBZ) Samples for Total Particulate and Elements
USFS, Kisatchie National Forest, July 14-17, 1996
HETA 93-1035

Employee	Sampling Dates	Flow Rate (L/min)	Sample Volume (L)	Concentrations of Total Particulate and Elements (mg/m^3)								
				Total Particulate mg/m^3	Be	Cd	Mg	Mn	Pb	Ti	Zn	Elements in trace concentrations
Forester A	7/14-17/97	2	685 700 694 596	0.26 0.03 0.21 0.38	0.00003 ND ND ND	ND ND ND ND	0.002 Trace Trace Trace	0.0002 0.0002 0.0001 0.0005	Trace ND ND ND	0.0004 0.0004 0.0004 0.0008	Trace Trace Trace 0.0018	Barium Chromium Phosphorus Selenium
Forester B	7/14-17/97	2	680 no sample 653 556	0.31 No sample 0.40 0.30	ND No sample ND ND	ND No sample Trace ND	0.0029 No sample 0.0014 Trace	0.0002 No sample 0.0003 0.0001	ND No sample ND ND	0.0008 No sample 0.0006 0.0004	Trace No sample ND ND	Barium Chromium
Forester C	7/14-17/97	2	664 706 658 685	0.77 0.54 0.56 0.60	Trace ND ND ND	ND Trace ND ND	0.0035 0.0017 0.0015 0.0020	0.0006 0.0003 0.0003 0.0003	ND ND ND ND	0.0012 0.0007 0.0008 0.0007	Trace Trace Trace Trace	Cobalt Chromium Lithium Nickel
Forester D	7/14-17/97	2	516 705 682 720	0.13 0.21 0.31 0.28	ND ND ND ND	ND ND ND ND	0.0021 0.0015 0.0015 Trace	0.0004 0.0002 0.0003 0.0001	ND Trace ND ND	0.0009 0.0005 0.0005 0.0005	Trace Trace Trace Trace	Barium Chromium Zirconium
Forester E	7/14-17/97	2	618 642 726 635	0.15 0.17 0.16 0.17	ND ND ND ND	ND ND ND ND	Trace Trace Trace Trace	0.0002 0.0005 0.0002 0.0001	ND ND ND ND	0.0003 0.0006 Trace 0.0006	Trace ND Trace ND	Barium Chromium

Table 8 (Continued)

Employee	Sampling Dates	Flow Rate (L/min)	Sample Volume (L)	Concentrations of Total Particulate and Elements (mg/m^3)								
				Total Particulate mg/m^3	Be	Cd	Mg	Mn	Pb	Ti	Zn	Elements in trace concentrations
Forester F	7/14-17/97	2	596 631 704 716	0.18 0.32 0.38 5.21	ND ND ND ND	ND ND ND ND	Trace 0.0016 0.0013 Trace	0.0002 0.0003 0.0003 0.0001	ND ND ND Trace	0.0003 0.0004 0.0004 0.0003	Trace Trace Trace Trace	Barium Chromium
Forester G	7/14-17/97	2	615 671 732 606	0.21 0.13 0.19 0.18	ND ND ND ND	ND ND ND ND	Trace 0.0012 Trace Trace	0.0001 0.0001 0.0002 Trace	Trace ND ND ND	ND 0.0003 0.0003 Trace	Trace Trace Trace ND	Chromium
Forester H	7/14-17/97	2	619 650 743 614	1.87 0.20 0.26 0.24	ND ND ND ND	ND ND ND ND	0.0015 0.0016 Trace Trace	0.0002 0.0003 0.0002 0.0001	Trace ND ND Trace	0.0003 Trace 0.0003 0.0003	Trace Trace Trace Trace	Barium Chromium Zirconium
MDC				0.03	0.000006	0.00004	0.0003	0.000006	0.0008	0.0001	0.0003	
MQC				-	0.00002	0.0002	0.0010	0.00002	0.0026	0.0003	0.0010	
NIOSH REL				none	0.005	0.2	-	1	<0.1	0.2	5	
OSHA PEL				15	0.002	0.01	10	5	0.05	10	10	
ACGIH™ TLV™				10	0.002	0.01	-	0.2	0.05	10	5	

MDC = minimum detectable concentration
MQC = minimum quantifiable concentration
trace = amounts between the MDC and MQC
mg/m^3 = milligrams per cubic meter
$\mu g/m^3$ = micrograms per cubic meter
NIOSH REL = National Institute for Occupational Safety and Health recommended exposure limit
OSHA PEL = Occupational Safety and Health Administration permissible exposure limit
ACGIH™ TLV™ = American Conference of Governmental Hygienists Threshold Limit Value

Table 9
Results of Urine Sample Analysis
USFS, Wallowa-Whitman National Forest, July 14-17, 1997
HETA 93-1035

Employee	Urine Volume (mL)	Results - Methyl Ethyl Ketone in Urine				
		(pre) 7/14/97	(post) 7/14/97	(post) 7/15/97	(post) 7/16/97	(post) 7/17/97
Forester A	30	0.22	0.15	0.22	0.24	0.13
Forester B	30	0.23	0.12	No sample	0.24	<0.10
Forester C	30	NA	<0.10	<0.10	<0.10	<0.10
Forester D	30	<0.10	0.14	0.13	0.10	<0.10
Forester E	30	0.18	0.16	0.77	0.42	0.28
Forester F	30	0.18	0.16	0.14	0.16	<0.10
Forester G	30	<0.10	0.29	0.17	0.32	0.15
Forester H	30	NA	<0.10	<0.10	<0.10	<0.10
ACGIH™ BEI™ ‡		2 mg/L*				
Limit of Detection (LOD)		0.10 mg/L				

‡ = American Conference of Governmental Industrial Hygienists Biological Exposure Index
** = The BEI of 2.0 mg/L corresponds to the TLV™ of 200 ppm of MEK.
NA = not analyzed, pre samples were not analyzed if all post shift samples were below the limit of detection of 0.10 mg/L
mg/L = milligrams per liter

SECTION 2
Epidemiologic Study of Adverse Reproductive Outcomes among Women in the U.S. Forest Service

Richard J. Driscoll, Ph.D., M.P.H.

METHODS

Women in all job categories throughout the Forest Service, currently employed for at least one year, and within the age range of 18-52 at the time of the survey, were invited to participate in this study. This age range included the majority of reproductive age women during the 10-year period of study. Representatives from the Forest Service Office of Personnel identified 10,329 women who were eligible to participate. Men and part time seasonal workers were excluded from the study to limit overall project costs, improve response reliability, and facilitate data retrieval (records for part-time seasonal workers were not centrally located and retrieval of their records would be difficult to standardize).

Questionnaire Development and Distribution

Participants completed self-administered questionnaires in which they were asked to provide job duties and reproductive history for a 10-year period beginning January 1, 1986 , through January 1, 1996 (Appendix A). The period of study was selected to capture changes in sole source paint supply contracts and improve the power of the study to detect a difference in adverse reproductive outcomes between work groups. Questions used in the reproductive questionnaire were field tested with the assistance of 55 women from the U.S. Department of Interior who were responsible for marking trees on Department of Interior lands.

Given the length of the study period, concerns over the validity of quantitative exposure recall were addressed by restricting self-reported exposure assessment to a yes/no dichotomy and coupling exposure recall to a period immediately preceding each reported pregnancy. Thus, participants were asked for each listed pregnancy whether they had been exposed to a variety of occupational and non-occupational factors at anytime up to 6-months prior to that pregnancy.

Questionnaires labeled with a unique identification number known only to the principal investigator were mailed directly to eligible workers. Additionally, participants were provided self-addressed, postage-paid business reply envelopes to return completed questionnaires to NIOSH. Each questionnaire included a note to recipients from the Director of the Forest Service, and one from the principal investigator encouraging participation and a timely response. All participation in the study was voluntary and no incentives were offered.

The initial distribution of 10,320 questionnaires yielded approximately 4200 responses. Because of the relatively low return rate from the first mailing, a second duplicate questionnaire was mailed in January 1997, to over 6000 non-respondents. In addition, follow-up electronic mail messages were sent to all Forest Service personnel to remind eligible workers to complete and return questionnaires to NIOSH.

Statistical Methods

We conducted statistical analyses to examine miscarriages and birth defects and their association with a variety of occupational and non-occupational factors potentially related to adverse reproductive outcomes. The research questions addressed by this study included:

- Are Foresters at increased risk of miscarriage or birth defects compared with all other workers in the USFS?

- If Foresters experience an increased risk of adverse reproductive outcomes, what exposures are associated with this increased risk?

Statistical analyses were performed using SAS® Ver. 6.12. Preliminary analyses included all respondents to determine their demographic characteristics and determine rates for births, miscarriages and birth defects. Bivariate relationships and multi-variate modeling of exposure and outcome relationships were restricted to respondents who reported one or more pregnancies during the study period. Because

multiple miscarriages are not considered independent events (an assumption for multi-variate logistic regression), regression modeling was conducted using the Generalized Estimation Equation (GEE), by means of SAS® Proc Genmod. The GEE method was selected for its utility in handling repeated, non-independent, binary outcomes and was thus an appropriate method for modeling predictors of adverse reproductive outcomes.[1]

Adverse Reproductive Outcomes Examined

Two adverse reproductive outcomes were considered in this study, self-reported miscarriage and self-reported birth defects. Respondents who selected #3 Miscarriage on question #32 (Birth outcome) and completed Section 2 (Miscarriages) were considered for the purposes of this study to have had a miscarriage. Similarly, women who answered "Yes" and named a specific birth defect to the question "Was your child born with any birth defect that was diagnosed by a doctor at birth?" or replied "Yes" and named a type of birth defect in response to: "Did a doctor find other birth defects in your child later?" were considered for the purposes of this study to have had a child with a birth defect. Additionally, narrative descriptions of each birth defect were reviewed and, where possible, grouped by phenotype.

Measures of Association

Rate ratios and odds ratios were used to measure the strength of association between the self-reported exposures and the two adverse reproductive outcomes separately (miscarriage and birth defects). The rate ratio (RR) is calculated as the rate of miscarriage or birth defects in the exposed group divided by the rate among the unexposed group. Similarly, the odds ratio (OR) is a ratio of the odds of miscarriage in the exposed divided by the odds of miscarriage in the unexposed. When either measure exceeds 1, then the rates or odds are higher in the exposed group than in the non-exposed group. As an example, a rate ratio of 3 would be interpreted as the exposed group having a 3-times greater risk of disease than the unexposed (or control) group. Conversely, a rate ratio of 0.5 would indicate that the risk of disease in the exposed group is half that of the unexposed. Each estimate of the odds ratio or rate ratio is followed by a 95% confidence interval. The confidence intervals are an indication of the statistical significance of the rate or odds ratio. For example, a 95% confidence interval of 1.10 to 2.00 indicates that we are 95% certain that the true odds ratio or rate ratio is somewhere in the range between 1.10 and 2.00. Conversely, this same range would suggest that there is a 5% chance that the true point estimate is beyond the range indicated.

RESULTS

Among the 10,329 women who were eligible to participate in this study, 6303 returned questionnaires; 6080 (59%) were sufficiently complete for use in this study. Respondents were grouped into two categories, Foresters (those presently in job series 460 and 462) and Non-foresters (those presently in all other job series classifications). Sixty-five percent (1383) of the eligible Foresters, and 57% (4697) of the eligible Non-foresters participated in the survey. Thus, Foresters were slightly over represented among participants (Table 1). Participating Foresters tended to be younger than Non-foresters (39 vs. 42 years respectively, $t=14.8$, $p<0.01$). The difference in years worked for the USFS between Foresters and Non-foresters was not significantly different (12.9 vs. 12.8 years respectively, $t=-0.73$, $p>0.5$). Foresters were more likely than Non-foresters to be white (93% vs. 87% respectively).

Thirty-four percent of the Foresters (464) and 23% of the Non-foresters (1073) reported one or more pregnancies during the study period. A total of 788 pregnancies was reported by Foresters and 1612 by Non-foresters.

Miscarriage Rates: Foresters vs. Non-foresters

We examined whether Foresters had a higher rate of miscarriage than Non-foresters. Foresters reported 141 miscarriages during this period, for a miscarriage rate of 18% (788 pregnancies, 141 miscarriages). Non-foresters reported 219 miscarriages for a miscarriage rate of 14% (1612 pregnancies, 219 miscarriages, OR 1.38, 95% Confidence Interval [CI] 1.07, 1.80). This relationship changed slightly (OR 1.42, 95% CI: 1.06, 1.90) after adjusting for the age of the mother at pregnancy, strenuous work activity, and the use of cigarettes and alcohol prior to pregnancy. The length of pregnancy before miscarriage was similar in the two groups (Foresters: mean week of miscarriage = 9.5, Non-foresters: mean week of miscarriage = 10.0, t=-1.60, p >0.9). Foresters were 38% more likely to report miscarriages than Non-foresters over the 10-year period.

Figure 1 shows the rate of miscarriages for both Foresters and Non-foresters for each year during the 10-year period. Overall, the yearly rates for Foresters shows no clear pattern over the 10-year period, while the rates for Non-foresters tended to be more stable, with a slight increase in rates over the same time period.

The Relationship Between Miscarriages and Work/Non-work Exposures

Each participant who reported a pregnancy during the 10-year study period was asked if she had been exposed to each of five different tree-marking paints and various non-work-related materials within the six months prior to a pregnancy. When we looked one at a time at work and non-work exposures (unadjusted) and their relationship with miscarriages, all of the tree-marking paints (OR ranged from 1.53 to 4.00), self-reported strenuous work (OR=1.48, 95% CI: 1.03, 2.11), and use of herbicides (OR=2.38, 95% CI: 1.21, 4.65) were associated with an increased risk of miscarriage (Table 2). OR for pesticide application, firefighting duties, and photography, showed slightly increased, but the confidence intervals included one.

Following this analysis, the relationships between these specific work related exposures and miscarriage were examined after adjusting for the effects of smoking, alcohol use, self reported strenuous work, and maternal age at each pregnancy. The adjusted OR for paint exposures again show an association with miscarriage, however, only the association between miscarriages and Nelson (OR=1.78, 95% CI: 1.21, 2.61), Nelson Boundary (OR=2.03, 95% CI: 1.24, 3.33), and Southern Coatings Boundary (OR=4.33, 95% CI: 2.02, 9.27) paints are statistically significant (Table 3). Additionally, the association of miscarriage with herbicide use remained statistically significant, though slightly attenuated, after adjusting for smoking, alcohol use, self reported strenuous work and maternal age at pregnancy (OR= 1.98, 95% CI: 1.10, 3.52).

In the preceding analyses, we examined the relationship between specific work exposures and miscarriages while simultaneously adjusting the statistical models for those variables known to increase one's risk for miscarriage (maternal age,[2] smoking,[3] alcohol use,[4] and strenuous work activity[5]). Because it is unlikely that a worker would have only one exposure at a time, it is necessary to model simultaneously the relationship between miscarriage and all of the work exposures we considered. Therefore, multi-variable exposure models were constructed that simultaneously adjusts for all *other* variables that appear in the model. Thus, each of the odds ratios noted in Table 4 are adjusted for other work exposures (use of other paints or herbicides) and potential confounding exposures (maternal age at pregnancy, strenuous work, alcohol use, smoking). Two of the five paints remained in the final model (Nelson OR=1.81, 95% CI: 1.21, 2.70; Southern Coatings Boundary OR=2.77, 95% CI: 1.11, 6.88). The use of herbicides was retained in the model despite having

a borderline statistical significance (OR=1.82, 95% CI: 1.00, 3.32).

This final model shows that (after simultaneously controlling for the potential confounding effects of strenuous work activities, maternal age at pregnancy, the use of alcohol and cigarettes, the use of Southern Coatings Boundary Paint, and herbicides) those who reported using Nelson paint (up to six months prior to a pregnancy) had an 81% increased risk of miscarriage. Similarly, after controlling for all of the above variables, and the use of Nelson paint, Southern Coatings Boundary paint was associated with a 177% increased risk of miscarriage, and use of herbicides was associated with an 82% increased risk of miscarriage.

Lastly, having a miscarriage increases the risk that a subsequent pregnancy will end in miscarriage.[6] This raises the question whether the increased risk for miscarriages among Foresters exposed to tree-marking paints was the result of prior miscarriages or the result of work related exposures. To answer this question, we eliminated from the analysis the 750 women who had a pregnancy prior to the study period. Eliminating women who had had a prior pregnancy slightly attenuated the point estimate for Nelson paint (OR=1.51, 95% CI: 0.93, 2.45), Southern Coatings Boundary paint (OR=2.67, 95% CI:0.75, 9.48) and for herbicide exposure (OR=2.56, 95% CI: 1.32, 4.95); however, only the point estimate for herbicide exposure was statistically significant.

Relationship Between Miscarriages and Preferred Method of Applying Paint

Tree painters have the option of using a one-quart paint gun or an aerosol can of paint. Table 5 indicates the type of paint and the percent of participants using each available method of paint application. Point estimates exceeded 1.0 for the relationship between miscarriage and all paint application methods, with the exception of the Panama paint gun. However, only the relationship between use of the Nelspot paint gun and miscarriage was statistically significant (OR=1.47, 95% CI: 1.08, 2.00).

Birth Defect Rate: Foresters vs. Non-foresters

Among Foresters, 32 women reported having 36 children with birth defects. Similarly, 65 Non-foresters reported having 73 children with birth defects. Overall, the risk of having a child with a birth defect appeared slightly higher among Foresters (OR)=1.17 95% CI: 0.85, 1.63; although the confidence interval included one. Additionally, we examined whether having a child with a birth defect was associated with having one or more parents reporting their job title as Forester. Thus we examined the association between both parents being Foresters, mother only being a Forester, or only the father being a Forester, and the odds of having a child with a birth defect (compared with Non-foresters as the referent group). Having both parents being Foresters was associated with an increased risk of having a child with a birth defect (OR 2.00, 95% CI: 1.04, 8.08); the remaining Forester-parent combinations all had confidence intervals that included 1.

The records from each respondent who indicated having a child with a birth defect were individually reviewed. Four different birth defects/conditions were mentioned more than three times, Down syndrome, hypospadiasis, heart murmur, and defects confined to the eyes. All four reported cases of Down syndrome and all eight cases of hypospadiasis were reported among children of Non-foresters. Twenty children had heart murmurs, 10 each among children of Foresters and Non-foresters. Thus, Foresters were more likely to report having children with heart murmurs compared with Non-foresters, but the confidence interval included 1. (OR=2.05, 95% CI: 0.80, 5.40). Repeating the analysis to determine the relationship between having one or more parents being Foresters and having a child with a heart murmur, compared to Non-foresters, shows that the risk of having a child with a heart murmur

increases when both parents are Foresters; however, the confidence interval includes 1 (OR= 4.66, 95% CI: 0.88, 24.53). Note: Having both parents reporting their occupation as Forester was only associated with birth defects, and not associated with reported miscarriages.

The Relationship Between Birth Defects and Work/Non-work Exposures

Each participant who reported a pregnancy during the 10-year study period was asked if they had been exposed to each of five different tree-marking paints and various non-work-related materials, up to six months prior to each pregnancy. When we looked one at a time at work and non-work exposures (unadjusted) and their relationship with birth defects, seven exposure items had elevated OR (Southern Coatings Paint and Southern Coatings Boundary Paint, Nelson Paint and Nelson Boundary Paint, herbicides, pesticides, and physically strenuous work tasks [Table 6]). However, the highest OR was 1.6, and all had confidence intervals that included 1.

DISCUSSION

The results of this study have shown miscarriages to be associated with:

- Work as a Forester,
- Use of herbicides,
- Use of Nelson tree-marking paint, and
- Use of Southern Coatings Boundary paint.

In addition, we found birth defects (all birth defects combined, and heart murmurs specifically) to be associated with work as a Forester at the time of pregnancy and both parents being Foresters.

Given the results of this study, we have two options to consider:

1. The associations observed are real, thus; suggesting that there is something in the paints and herbicides that increased the risk of adverse reproductive outcomes among those women who were exposed to these materials prior to or during pregnancy. Because of the design of the study we will never be able to definitively establish a causal link, but the argument is position can be supported if we can establish that the paints and/or herbicides did contain known reproductive toxicants, and then demonstrate that similar findings have been observed elsewhere.

Or:

2. The associations observed in this study were the result of chance or systematic errors in the study rather than a true causal association.

In the sections that follow, we will discuss each of these possibilities. First, we will examine what we know about the paints, when they were used, and whether the paints and herbicides are known to be, or contain, reproductive toxicants. Lastly, we will discuss the strengths and weaknesses of the study and examine whether there are alternative (non-causal) explanations for the associations reported, such as a selection or response bias.

Biologic Plausibility for the Association between Work Site Exposures and Adverse Reproductive Outcomes

What is Known about the Paint

Forest Service records indicate that Nelson paint was used until 1988, at which time the Southern Coatings Paint Company became the sole source supplier of tree-marking paints. From 1990 to the end of the study period, Niles Inc. was the sole supplier of tree-marking paints for the USFS. Therefore, the two paints associated with miscarriages in this study have not been officially purchased since 1990; however, reports from Foresters in the field suggest that these paints can still be found in storage facilities in some

locations. Additionally, participants in this study reported using Nelson paint as late as 1995.

Reproductive Toxins and Tree-marking Paint

The MSDS for both Nelson and Southern Coatings paints, confirms that these paints had at one time, constituents that have been associated with adverse reproductive outcomes, specifically lead and organic solvents. Performance contracts for the paint prohibited lead in the paints by the time the contract was awarded to Niles Inc.

Adverse Reproductive Outcomes Associated with Exposure to Lead

MSDS for the paints indicate that the pigments used were composed of 4-60% (by weight) lead. Additionally, correspondence from a physician contracted to sample blood lead levels (BLL) among Foresters in the Allegheny National Forest in 1982 (the only record of biological sampling for lead that was found in the USFS files), indicates that the highest lead level recorded was 17 micrograms per deciliter (µg/dL). Rom reviewed the scientific literature for the reproductive consequences of lead exposure and reported a series of studies that encompassed approximately 100 years of research.[7] Outcomes associated with lead exposure include increased risk of miscarriage, abnormal spermatogenesis, infertility (both men and women), lower birth weights, and birth defects. More recent studies, in which lower occupational and environmental exposures to lead are reported, do not show a strong relationship between exposure to low levels of lead and miscarriage. A cohort study conducted by McMichael et al. examined the reproductive outcome of 831 pregnant women in Australia who lived in the vicinity of a lead smelter.[8] Twenty-four miscarriages occurred during the study period, 23 among the exposed townspeople, and 1 among the unexposed. However, this study found no association between maternal BLL (mean 10.8 ± 0.15 µg/dL) and miscarriage, but did find an association between maternal BLL and both preterm delivery and lower birth weight. A similar study conducted by Murphy et al. in which they compared rates of miscarriage among women living in the proximity of a lead smelter in Yugoslavia, also failed to show a statistically significant association between lead exposure (mean exposure 0.77 micromoles per liter (µmol/L) [~ 15.9 µg/dL]) and miscarriage (OR=1.1, 95% CI: 0.9, 1.4).[9] Lindbohm et al. found paternal exposure above 31 µg/dL to increase the risk of miscarriage by 40% (OR=1.4, 95% CI: 0.5-3.5).[10] None of the point estimates for the association between lead exposure and miscarriage were statistically significant.

Adverse Reproductive Outcomes Associated with Exposure to Organic Solvents

MSDS for paints used in 1986 show that they consisted of approximately 35-40% by weight petroleum distillates. Exposures to organic solvents have been shown to increase the risk for adverse pregnancy outcomes [11,12,13,14] and reduce fertility.[15] In a case control study measuring occupational exposure to organic solvents, exposure to perchloroethylene, trichloroethylene, and paint thinners resulted in a doubling of the risk of miscarriage.[11] The authors were not able to show a dose response with regard to these solvents. The ability for solvents to solubalize lipids suggests that solvents can pass through the placenta into the fetus.[13]

Lipscomb et al., in a study of pregnancy outcomes among approximately 1000 women, report that regular and daily solvent exposures were associated with an increased odds of miscarriage (OR=3.34). Additionally, solvent exposure was associated with low birth weight infants (OR=1.42).[15] Agnesi, Valentini and Mastrangelo, report an increased risk of miscarriage among women exposed to organic solvents during pregnancy.[16] Among 108 cases and

controls, the risk of miscarriage among the high exposed group was 3.85 (95% CI: 1.24-11.9). Axelson and Rylander were able to show a 31% increased risk of miscarriage among laboratory workers who were exposed to solvents.[17]

Adverse Reproductive Outcomes Associated with Exposure to Herbicides

The association between herbicide exposure and miscarriage has been noted in a number of large epidemiologic studies. Wolfe et al., examined Vietnam Veterans and their risk of miscarriage.[18] The exposure of interest was dioxin from Agent Orange. Those veterans categorized in the low dioxin and background dioxin groups were found to be at increased risk of miscarriage. Forsber and Nordstrom studied the reproductive history of women who lived in the vicinity of a herbicide manufacturing plant.[19] Women who were in the exposed group had more than twice the risk for miscarriages than the women in the unexposed group. In a review of studies examining the relationship between herbicide exposure and adverse pregnancy outcomes, Savitz et al. concluded that the association between miscarriage and herbicide exposure was weak.[20]

Methodological Strengths and Weaknesses of this Study

This study's 60% response rate is considered reasonably good for a mailed, self-administered questionnaire; however, it is unclear whether reproductive and exposure histories of non-respondents would differ from those who did respond. Age, years of work for the Forest Service, and job series distribution were comparable between respondents and non-respondents, indicating that study participants were, to the extent we were able to measure, comparable to non-respondents. The response rate among Foresters, however, was slightly higher than that among Non-foresters (65% vs. 57% respectively). Because the concern over a potential work association with miscarriages originated among Foresters, an argument can be made that Foresters were more likely to participate in this study and were more likely to report a miscarriage than Non-foresters (response bias[21]). If we assume that all of the Foresters who had miscarriages participated, and the remaining Foresters had no miscarriages, then the true miscarriage rate for Foresters would be lower than observed. Conversely, because the concern over miscarriages did not originate among Non-foresters, those Non-foresters who did have a miscarriage may have decided not to participate. The result of their non-participation and under reporting would be that our results for Non-foresters would be artificially low. A study of spontaneous abortion among women exposed to anesthetic gases found a strong response bias among exposed persons.[22] One-third of the miscarriages among the unexposed group were not reported on the mailed questionnaire. Thus, if we consider the potential for response bias and an under reporting of miscarriages among Non-foresters, then the true rate ratio comparing miscarriages among Foresters and Non-foresters would be closer to one, indicating lower or no risk.

Another methodological issue in this study is recall bias.[23] Women who have had a miscarriage or a child with a birth defect are likely to methodically review a pregnancy for potential causes (such as in this study, the use of paints, herbicides, or hazardous materials). Thus, it is possible that women in this study who had one or more miscarriages or children with birth defects were more likely to recall and report using potentially hazardous materials before or during a pregnancy than women who had a living healthy child. Recall bias, while difficult to correct or evaluate, should be considered when interpreting the results of this study

Limitations of Exposure Quantification and Identification

With regard to herbicides, we asked participants only if they had used herbicides, and not the type or brand

of the herbicide used. Thus, we are not able to explore this relationship further.

The observed association between Southern Coatings Boundary paint and miscarriages is based upon small numbers. Among those who reported having a pregnancy during the study period, only 25 workers reported using this paint preceding a pregnancy, however, of these 25, 10 (40%) reported having a subsequent miscarriage. The magnitude of the association could be reduced or become non-significant if, among the non-respondents, there are workers who used this paint and had a normal delivery subsequent to the exposure. For example, the estimated OR for the association between Southern Coatings Boundary paint and miscarriage could become 1 (showing no difference in the odds of miscarriage between the exposed and non-exposed groups) with as few as 93 workers in the non-response group reporting that they used this paint within 6 months of a normal pregnancy. The following calculations, however show that such a scenario is unlikely. Of the 2338 women who reported a pregnancy, only 25 reported they had used this paint prior to a pregnancy (0.01%). If we assume that the same percentage of the population had one or more pregnancies in the non-participant group as was found in the participant group (38%), then we could expect that 1520 of the non-respondents could have been pregnant during the study period (0.38 X 4000), and thus, only 15 of these workers could be expected to have used Southern Coatings Boundary paint prior to a pregnancy (0.01 X 1520). Although it is possible that there are more people in the non-response group who may have used Southern Coatings Boundary paint prior to a pregnancy, it is unlikely that there are enough to eliminate the association observed in this study.

CONCLUSIONS

This study was conducted to determine whether Foresters were at increased risk for adverse reproductive outcomes and, if so, what exposures contributed to the risk. The results of this study have shown that women Foresters who used Nelson paint, Southern Coatings Boundary paint, or used herbicides, were more likely than Non-Foresters to report miscarriages. Furthermore, families in which both parents were Foresters, were more likely to report having a child with a birth defect.

To address the issue of biologic plausibility, we examined tree-marking paint formulations as for ingredients that have been shown in the scientific literature to cause either miscarriages or birth defects. The paint formulations indicated two components that, given sufficient exposure, could be responsible for miscarriages. These ingredients were lead-based pigments and organic solvents. Furthermore, the scientific literature indicates that exposure to some herbicides increase the risks for some birth defects, however, whether Foresters were exposed to the implicated herbicides is unknown.

Absent from this study are quantitative exposure data. The industrial hygiene component of this HHE, which measured work-related exposures for present day tree markers (see industrial hygiene report for full details), showed relatively low exposures to metals and organic solvents. Given that past exposures (based upon present day working conditions and practices) would have been comparably low, the question remains whether chronic low-level exposures to lead, organic solvents, herbicides, or pesticides result in an increased risk for miscarriages or birth defects. Previous studies do not generally support the contention that low- level lead exposure causes miscarriages. The literature describing the reproductive effects of low level exposure to organic solvents, however, does suggest that fetal loss is associated with such exposures. Furthermore, the magnitude of effect reported in the studies reviewed is consistent with the effect estimates detailed in this study.

Southern Coatings Paint is no longer made and Nelson paint is no longer purchased for use by the USFS. Supplies of these materials reportedly still exist, however, and may be available in storage lockers throughout the Forest Service. Furthermore,

despite removing all exposures to paints, Foresters could continue to be at risk for adverse reproductive outcomes because of the physically demanding nature of the job, and the continued exposure to herbicides and pesticides (all of which were independent predictors of adverse reproductive outcomes).

RECOMMENDATIONS

Based upon results obtained during four site visits to four National Forests, and the epidemiologic study of adverse reproductive outcomes among Forest Service workers, NIOSH recommends that the following steps be taken to reduce employee exposures while marking timber:

1. The USFS should investigate using alternative tree-marking paint. High solids, low solvent, or water-based marking paints such as acrylic latex enamels should be selected and field tested. Low solvent or water-based paints, which are found to be less irritating to employees and do not cause acute CNS health effects, should be available for employee use. Furthermore, steps should be taken to collect and properly dispose of any old supplies of Nelson or Southern Coatings paints.

2. The amount of paint used should be minimized by encouraging employees to use the minimum trigger pulls required to mark a single tree. One stump dot applied first, followed by breast blazes may be helpful to avoid exposing the employees' breathing zone to paint mists while marking at ground-level. Employees should be made aware that accumulated paint on clothing can volatilize off clothing and result in low-level exposures in the employees' breathing zone even when an employee is not marking timber.

3. The USFS should continue the policy of marking trees from an upwind position whenever possible. This may not always be feasible and can be difficult to follow depending on terrain and other circumstances. However, employees should be informed of the rationale for the policy. It should be stressed to employees that limiting all exposures to paint mist and vapor is important.

4. Many of the components in paint can be absorbed through the skin. Therefore, NIOSH recommends protecting exposed skin with gloves, long sleeves, and pants. Clothes or PPE that become saturated with paint due to a spill should be changed to avoid prolonged skin contact. Also, workers should clean paint off their hands and face before eating, drinking, or smoking. Waterless hand cleaning products are available which clean and sanitize hands in field situations. Using solvents to clean skin is not recommended as they can cause or aggravate irritant contact dermatitis. Also, the solvent can be absorbed through the skin and contribute to worker exposures.

The Forest Service has been actively seeking alternative methods for marking trees. Through the Forest Service Paint Committee and the Office of Health and Safety, paint manufacturers have been asked to develop low solvent paint alternatives for tree-marking. In addition, non-paint methods are being considered. NIOSH encourages the Forest Service management to solicit and allow employee input toward any changes to employee work practices or product substitution proposed for implementation.

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Table 1 Comparability of Participants and Non-Participants (Age and Years Worked)						
	Participants n=6080		**Non-Participants** n=4280		**Eligible Workers** N=10329	
	Foresters n=1383 (23%)	**Non-foresters** n=4697 (77%)	**Foresters** n=725 (17%)	**Non-foresters** n=3555 (83%)	**Foresters** N=2066 (20%)	**Non-foresters** N=8263 (80%)
Mean age	39	42	39	41		
Mean Forestry Years	12.9	12.7				

Table 2 Work and Non-work exposures and Miscarriages Exposures up to 6 Months Prior to Pregnancy* (unadjusted odds ratios)			
Variable	**Pregnancy Outcomes N=2338**	**Odds Ratio**	**95% CI**
Southern Coatings Boundary	2203	4.00	1.89, 8.41
Herbicides	2250	2.38	1.21, 4.65
Nelson Boundary	2230	2.10	1.34, 3.30
Nelson	2233	1.64	1.18, 2.28
Southern Coatings	2208	1.64	1.03, 2.61
Niles	2217	1.53	1.01, 2.33
Strenuous Job	2276	1.48	1.03, 2.11
Pesticides	2248	1.14	0.54, 2.40
Fire Fighter	2272	1.14	0.86, 1.51
Photographer	2315	1.10	0.28, 4.34
Maternal age at pregnancy	2189	1.08	1.04, 1.33
Smoking	2315	0.99	0.64, 1.64
Alcohol	2303	0.84	0.62, 1.16
Pottery	2312	0.33	0.07, 1.5
* Each row represents a separate statistical model			

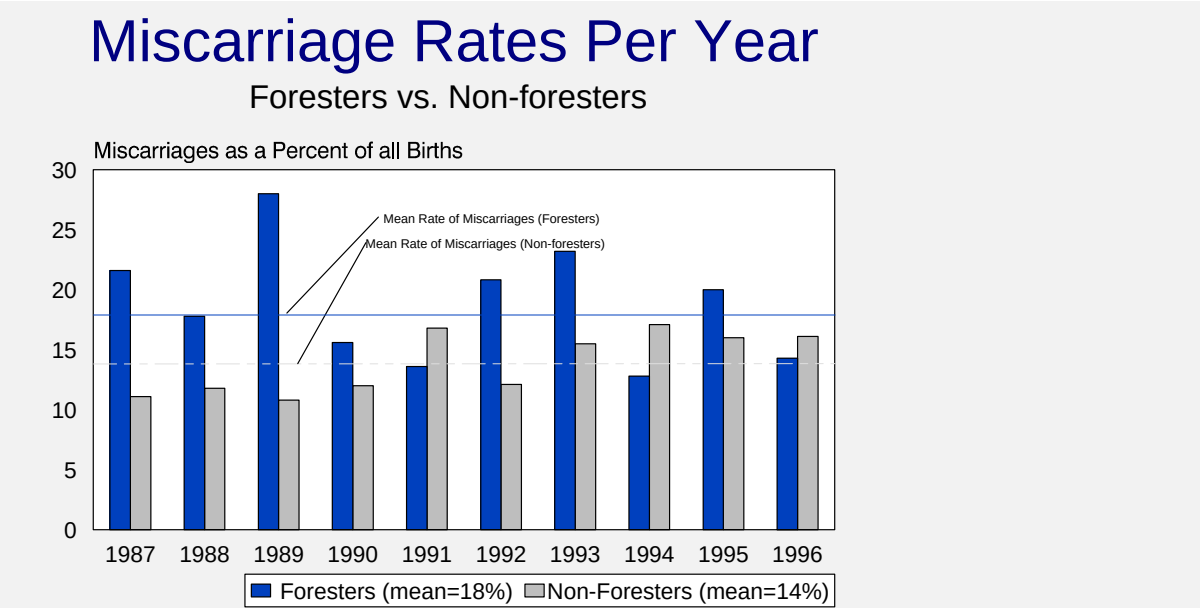
Table 3 Relationship Between Single Work Exposures and Miscarriages*			
Exposure	**Pregnancy Outcomes N=2338**	**Adjusted Odds Ratio***	**95% Confidence Interval**
Southern Coatings Boundary	2044	4.33	2.02, 9.27
Nelson Boundary	2063	2.03	1.24, 3.33
Herbicide Use	2090	1.98	1.10, 3.52
Nelson	2066	1.78	1.21, 2.61
Southern Coatings	2051	1.60	0.96, 2.64
Niles	2056	1.46	0.92, 2.29
* adjusted for maternal age at pregnancy, self-reported strenuous work, smoking and alcohol use. (Each Row Represents a Separate Logistic Regression Model			

Table 4 Multivariate Model: Work Exposures and Miscarriages, Simultaneously Adjusting for the Presence of Other Paints, Herbicide Use, and Potential Confounding Exposures* n=2030 pregnancy outcome		
Exposure	**Adjusted* Odds Ratio**	**95% Confidence Interval**
Southern Coatings Boundary	2.77	1.11, 6.88
Herbicides	1.82	1.00, 3.32
Nelson Paint	1.81	1.21, 2.70
*adjusted for maternal age at pregnancy, self-reported strenuous work, smoking and alcohol use, and the remaining two variables listed.		

Table 5 Preferred Paint Application Method		
	Paints	
Application Method	**Nelson**	**Southern Coatings Boundary**
Nelspot Paint Gun	32%	30%
Panama Paint Gun	0.5%	-
Aerosol Can	16%	-
Paint Gun and Aerosol Can	51%	49%

Table 6 Work and Non-work Exposures and Birth Defects Exposures up to 6 Months Prior to Pregnancy* (unadjusted odds ratios)			
Variable	**Pregnancy Outcomes N=2338**	**Odds Ratio**	**95% CI**
Southern Coatings Boundary	2203	1.60	0.61, 4.22
Pesticides	2250	1.56	0.71, 1.42
Nelson Boundary	2230	1.44	0.91, 2.28
Herbicides	2250	1.33	0.85, 2.10
Nelson	2233	1.19	0.88, 1.61
Southern Coatings	2208	1.18	0.75, 1.85
Strenuous Job	2276	1.11	0.88, 1.42
Pottery	2317	1.02	0.51, 2.01
Fire Fighter	2272	1.01	0.81, 1.27
Niles	2217	0.88	0.55, 1.42
Alcohol	2303	0.85	0.65, 1.11
Maternal age at pregnancy	2189	0.78	0.48, 1.28
Smoking	2315	0.99	0.64, 1.64
* Each row represents a separate statistical model			

Figure 1


Miscarriage Rates Per Year
Foresters vs. Non-foresters
Miscarriages as a Percent of all Births
30
25
20
15
10
5
0
Mean Rate of Miscarriages (Foresters)
Mean Rate of Miscarriages (Non-foresters)
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
Foresters (mean=18%)
Non-Foresters (mean=14%)

APPENDIX A

Example of the Reproductive Questionnaire Used in this Study

Form Approved OMB No. 0920-0260
Expires Aug. 31, 1997

U.S. Department of Health and Human Services
U.S. Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

HETA 93-1035 U.S. Forest Service Employees

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)
CENTERS FOR DISEASE CONTROL AND PREVENTION
U.S. PUBLIC HEALTH SERVICE
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

CONSENT TO PARTICIPATE IN A HEALTH HAZARD EVALUATION

I. You are being asked to participate in a NIOSH health hazard evaluation of adverse reproductive outcomes among U.S. Forest Service workers. This health hazard evaluation was requested by your fellow workers and representatives from the Forest Service Safety Office because of reports of miscarriages, still births, and birth defects among some women employed by the Forest Service.

II. The study will consist of a questionnaire about your work history, health history, and health-related activities, including specific questions about your reproductive history. You will be asked to complete the questionnaire and return it directly to NIOSH in an envelope provided. It should take from 20-45 minutes to complete the questionnaire.

III. Participation in this study will help determine whether certain jobs within the U.S. Forest Service have an increased risk of adverse reproductive outcomes. This information will be useful to characterize the reproductive risk of groups rather than individuals, thus, individual benefits from participation in this study are limited Your participation may benefit your co-workers and possibly other people, as a result of what is learned from this study. The overall study results (without names or other personal identifying information) will be provided to the Forest Service and union (or other employee representative); the Forest Service is also required to post a copy of the final report in a place accessible to employees for a period of 30 days. In addition, if you so request, NIOSH will send you a copy of the final report.

IV. This is a self administered questionnaire and, therefore, you should not experience any direct risk of injury or discomfort as a result of your participation. If you have any questions about this research or your participation in this study, contact NIOSH Technical Support Personnel at (1-800-356-4674 select option 5 and identify yourself as a Forest Service employee).

V. The National Institute for Occupational Safety and Health (NIOSH) of the Centers for Disease Control and Prevention (CDC), an agency of the Department of Health and Human Services, is authorized to collect this information, including your social security number, under provisions of the Public Health Service Act, Section 301 (42 U.S.C. 241); Occupational Safety and Health Act, Section 20 (29 U.S.C. 669); and Federal Mine Safety and Health Act of 1977, Section 501 (30 U.S.C. 95). The data will be used to evaluate the relationship between work related exposures and reproductive outcomes among Forest Service workers. Data will become part of CDC Privacy Act system [09-20-0147, "Occupational Health Epidemiological Studies"] and may be disclosed: to private contractors assisting NIOSH; to collaborating researchers under certain limited circumstances to conduct further investigations; to one or more potential sources of vital statistics to make a determination of death; to the Department of Justice in the event of litigation; and to a congressional office assisting individuals in obtaining their records. An accounting of the disclosures that have been made by NIOSH will be made available to you upon request. Except for these and other permissible disclosures expressly authorized by the Privacy Act, no other disclosure may be made without your written consent.

VI. Your participation is voluntary and you may withdraw your consent and your participation in this study at any time without penalty or loss of benefits to which you are otherwise entitled.

VII. **SIGNATURE**: I have read this consent form and I agree to participate in this study.

PARTICIPANT _____ Age _____ Date_____
(signature)

Part 1. Introductory Information

Please answer each of the following questions by either filling in the blank or circling the appropriate response. All answers should be clearly marked in the spaces provided.

1. Date of Birth _____ / _____ / _____
   month day year

2. Please indicate your Race or Ethnicity (Circle one number only)

   White 1
   Black 2
   Asian / Pacific Islander. 3
   American Indian / Alaska Native. 4
   Other 5

3. Are you of Hispanic origin or descent? (circle one number)
   Yes 1
   No 0

4. Marital Status (circle one number)

   Married 1
   Single 2
   Separated / Divorced 3
   Widowed 4
   Live with a partner 5

5. Indicate the highest grade completed in school (circle one number only).

   No formal schooling 1
   Grades 1-8 (elementary school) 2
   Grades 9-11 (some high school). 3
   Grade 12 (high school grad) or GED. . . .4
   Vocational School 5
   Some college or 2-year college graduate. .6
   College graduate 7
   (Some) graduate school, master's or higher degree 8

6. Current Forest Service Occupational Series Number (specify the 4-digit number) _____

7. GS Rating / Grade GS ____

8. Forest Service Region Region # _____

9. How many years have you worked for the Forest Service? _____ years

10. Were you pregnant at any time between Jan 1, 1987 and Jan 1, 1996 ? Yes . . . 1 No. .. . 0

If you were not pregnant at any time during this period, (January 1, 1987 to January 1, 1996) please stop and return the questionnaire directly to the **National Institute for Occupational Safety and Health** in the self-addressed envelope that is included in your response packet. Thank you for your participation.

If you were pregnant at any time during this period, please continue with question # 11

11. Spouse's current occupation (if applicable):

_____

Have you ever used the following during your work with the Forest Service? (Circle one number)

12. **Niles** Tree-marking Paint Yes.....1 No.....0

12.A If **YES** did you usually use:
Nelspot Paint Guns .....1 Panama Paint Guns 2
Aerosol Spray Cans.....3 Used both a paint gun and aerosol can.....4

13. **Southern Coatings** Tree-marking Paint Yes.....1 No.....0

13.A If **YES** did you usually use:
Nelspot Paint Guns .....1 Panama Paint Guns 2
Aerosol Spray Cans.....3 Used both a paint gun and aerosol can.....4

14. **Nelson** Tree-marking Paint Yes.....1 No.....0

14.A If **YES** did you usually use:
Nelspot Paint Guns .....1 Panama Paint Guns 2
Aerosol Spray Cans.....3 Used both a paint gun and aerosol can.....4

15. **Nelson** Boundary Paint (Land Line Paint) Yes.....1 No.....0

15.A If **YES** did you usually use:

Nelspot Paint Guns .....1 Panama Paint Guns 2
Aerosol Spray Cans.....3 Used both a paint gun and aerosol can.....4

16. **Southern Coatings** Boundary Paint (Land Line Paint) Yes.....1 No.....0

16.A If **YES** did you usually use:
Nelspot Paint Guns .....1 Panama Paint Guns 2
Aerosol Spray Cans.....3 Used both a paint gun and aerosol can.....4

17. If you answered yes to any of the questions (11-15) did you ever wash off the paint residue from your skin with:

1. Paint Thinner Yes.....1 No.....0
2. Gasoline Yes.....1 No.....0
3. WD-40 Yes.....1 No.....0

18. Did you apply pesticides as part of your job ? Yes.....1 No.....0

19. Did you apply herbicides as part of your job? Yes.....1 No.....0

20. How would you describe your job with the Forest Service?: (Circle one number)

Office based.....1
Field based.....2
Combined Office and Field.....3

21. How would you describe the physical activity of your job?

Sedentary.....1
Somewhat sedentary.....2
Somewhat active.....3
Active 4
Strenuous.....5

Part 2 Reproductive History

This section asks questions about your reproductive history. In the event that these questions make you uncomfortable, or you do not wish to answer the question, then skip that question and move on to the next. (An extra page is provided at the back of the questionnaire to expand answers or add comments to any questions.)

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
1. Occupational Series during this pregnancy (4-digit number) _____	1. Occupational Series during this pregnancy (4-digit number) _____	1. Occupational Series during this pregnancy (4-digit number) _____	1. Occupational Series during this pregnancy (4-digit number) _____	1. Occupational Series during this pregnancy (4-digit number) _____	1. Occupational Series during this pregnancy (4-digit number) _____
2. Overall length of pregnancy from the end of the last menstrual period _____ weeks	2. Overall length of pregnancy from the end of the last menstrual period _____ weeks	2. Overall length of pregnancy from the end of the last menstrual period _____ weeks	2. Overall length of pregnancy from the end of the last menstrual period _____ weeks	2. Overall length of pregnancy from the end of the last menstrual period _____ weeks	2. Overall length of pregnancy from the end of the last menstrual period _____ weeks

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
3. In what month and year did this pregnancy end? _______/_______ month year	3. In what month and year did this pregnancy end? _______/_______ month year	3. In what month and year did this pregnancy end? _______/_______ month year	3. In what month and year did this pregnancy end? _______/_______ month year	3. In what month and year did this pregnancy end? _______/_______ month year	3. In what month and year did this pregnancy end? _______/_______ month year
4. How many months were you trying to get pregnant before conceiving? (convert years to months) ______________ months	4. How many months were you trying to get pregnant before conceiving? (convert years to months) ______________ months	4. How many months were you trying to get pregnant before conceiving? (convert years to months) ______________ months	4. How many months were you trying to get pregnant before conceiving? (convert years to months) ______________ months	4. How many months were you trying to get pregnant before conceiving? (convert years to months) ______________ months	4. How many months were you trying to get pregnant before conceiving? (convert years to months) ______________ months
5. Was this pregnancy conceived while taking fertility drugs? Yes........1 No.......0	5. Was this pregnancy conceived while taking fertility drugs? Yes........1 No.......0	5. Was this pregnancy conceived while taking fertility drugs? Yes........1 No.......0	5. Was this pregnancy conceived while taking fertility drugs? Yes........1 No.......0	5. Was this pregnancy conceived while taking fertility drugs? Yes........1 No.......0	5. Was this pregnancy conceived while taking fertility drugs? Yes........1 No.......0
6. How was pregnancy confirmed? (Circle the number of all that apply) Urine test ....1 Blood test ....2 Physical exam ....3 Other 4	6. How was pregnancy confirmed? (Circle the number of all that apply) Urine test ....1 Blood test ....2 Physical exam ....3 Other 4	6. How was pregnancy confirmed? (Circle the number of all that apply) Urine test ....1 Blood test ....2 Physical exam ....3 Other 4	6. How was pregnancy confirmed? (Circle the number of all that apply) Urine test ....1 Blood test ....2 Physical exam ....3 Other 4	6. How was pregnancy confirmed? (Circle the number of all that apply) Urine test ....1 Blood test ....2 Physical exam ....3 Other 4	6. How was pregnancy confirmed? (Circle the number of all that apply) Urine test ....1 Blood test ....2 Physical exam ....3 Other 4

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
7. Did a doctor or clinician confirm this pregnancy for you Yes.....1 No.....0	7. Did a doctor or clinician confirm this pregnancy for you Yes.....1 No.....0	7. Did a doctor or clinician confirm this pregnancy for you Yes.....1 No.....0	7. Did a doctor or clinician confirm this pregnancy for you Yes.....1 No.....0	7. Did a doctor or clinician confirm this pregnancy for you Yes.....1 No.....0	7. Did a doctor or clinician confirm this pregnancy for you Yes.....1 No.....0
8. Were you nauseated during the first trimester? Yes.....1 No.....0 (25)	8. Were you nauseated during the first trimester? Yes.....1 No.....0	8. Were you nauseated during the first trimester? Yes.....1 No.....0	8. Were you nauseated during the first trimester? Yes.....1 No.....0	8. Were you nauseated during the first trimester? Yes.....1 No.....0	8. Were you nauseated during the first trimester? Yes.....1 No.....0
9. How much did you weigh just prior to this pregnancy? _____ Pounds	9. How much did you weigh just prior to this pregnancy? _____ Pounds	9. How much did you weigh just prior to this pregnancy? _____ Pounds	9. How much did you weigh just prior to this pregnancy? _____ Pounds	9. How much did you weigh just prior to this pregnancy? _____ Pounds	9. How much did you weigh just prior to this pregnancy? _____ Pounds
10. How much weight did you gain during this pregnancy? _____ Pounds	10. How much weight did you gain during this pregnancy? _____ Pounds	10. How much weight did you gain during this pregnancy? _____ Pounds	10. How much weight did you gain during this pregnancy? _____ Pounds	10. How much weight did you gain during this pregnancy? _____ Pounds	10. How much weight did you gain during this pregnancy? _____ Pounds

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
11. Did you experience any of the following during this pregnancy? (Circle all that apply): Flu ....1 Rubella (Ger.measles)..2 Hepatitis.........3 Chicken Pox........4 Measles (Rubeola)...5 Mumps.........6 TB.........7 Toxoplasmosis.....8 Cytomegalovirus.....9 Gonorrhea.........10 Syphilis.........11 Yeast infection....12	11. Did you experience any of the following during this pregnancy? (Circle all that apply): Flu ....1 Rubella (Ger.measles)..2 Hepatitis.........3 Chicken Pox........4 Measles (Rubeola)...5 Mumps.........6 TB.........7 Toxoplasmosis.....8 Cytomegalovirus.....9 Gonorrhea.........10 Syphilis.........11	11. Did you experience any of the following during this pregnancy? (Circle all that apply): Flu ....1 Rubella (Ger.measles)..2 Hepatitis.........3 Chicken Pox........4 Measles (Rubeola)...5 Mumps.........6 TB.........7 Toxoplasmosis.....8 Cytomegalovirus.....9 Gonorrhea.........10 Syphilis.........11 Yeast infection....12 Trichomonas.......13 Non-Spec. Vaginitis...14	11. Did you experience any of the following during this pregnancy? (Circle all that apply): Flu ....1 Rubella (Ger.measles)..2 Hepatitis.........3 Chicken Pox........4 Measles (Rubeola)...5 Mumps.........6 TB.........7 Toxoplasmosis.....8 Cytomegalovirus.....9 Gonorrhea.........10 Syphilis.........11 Yeast infection....12 Trichomonas.......13 Non-Spec. Vaginitis...14 Herpes.....15	11. Did you experience any of the following during this pregnancy? (Circle all that apply): Flu ....1 Rubella (Ger.measles)..2 Hepatitis.........3 Chicken Pox........4 Measles (Rubeola)...5 Mumps.........6 TB.........7 Toxoplasmosis.....8 Cytomegalovirus.....9 Gonorrhea.........10 Syphilis.........11 Yeast infection....12 Trichomonas.......13 Non-Spec. Vaginitis...14 Herpes.....15	11. Did you experience any of the following during this pregnancy? (Circle all that apply): Flu ....1 Rubella (Ger.measles)..2 Hepatitis.........3 Chicken Pox........4 Measles (Rubeola)...5 Mumps.........6 TB.........7 Toxoplasmosis.....8 Cytomegalovirus.....9 Gonorrhea.........10 Syphilis.........11 Yeast infection....12 Trichomonas.......13 Non-Spec. Vaginitis...14 Herpes.....15

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
12. During the **3 months before you became pregnant** did you smoke at least an average of 1 cigarette per day? Yes......1 No......0 If Yes: 12.a About how many cigarettes did you usually smoke per day? __________ (# of Cigarettes) 12.b Did you smoke at least one cigarette per day at ANY TIME during this pregnancy? Yes......1 No......0 If Yes: 12.c How many months of the pregnancy did you smoke? Months_____	12. During the **3 months before you became pregnant** did you smoke at least an average of 1 cigarette per day? Yes......1 No......0 If Yes: 12.a About how many cigarettes did you usually smoke per day? __________ (# of Cigarettes) 12.b Did you smoke at least one cigarette per day at ANY TIME during this pregnancy? Yes......1 No......0 If Yes: 12.c How many months of the pregnancy did you smoke? Months_____	12. During the **3 months before you became pregnant** did you smoke at least an average of 1 cigarette per day? Yes......1 No......0 If Yes: 12.a About how many cigarettes did you usually smoke per day? __________ (# of Cigarettes) 12.b Did you smoke at least one cigarette per day at ANY TIME during this pregnancy? Yes......1 No......0 If Yes: 12.c How many months of the pregnancy did you smoke? Months_____	12. During the **3 months before you became pregnant** did you smoke at least an average of 1 cigarette per day? Yes......1 No......0 If Yes: 12.a About how many cigarettes did you usually smoke per day? __________ (# of Cigarettes) 12.b Did you smoke at least one cigarette per day at ANY TIME during this pregnancy? Yes......1 No......0 If Yes: 12.c How many months of the pregnancy did you smoke? Months_____	12. During the **3 months before you became pregnant** did you smoke at least an average of 1 cigarette per day? Yes......1 No......0 If Yes: 12.a About how many cigarettes did you usually smoke per day? __________ (# of Cigarettes) 12.b Did you smoke at least one cigarette per day at ANY TIME during this pregnancy? Yes......1 No......0 If Yes: 12.c How many months of the pregnancy did you smoke? Months_____	12. During the **3 months before you became pregnant** did you smoke at least an average of 1 cigarette per day? Yes......1 No......0 If Yes: 12.a About how many cigarettes did you usually smoke per day? __________ (# of Cigarettes) 12.b Did you smoke at least one cigarette per day at ANY TIME during this pregnancy? Yes......1 No......0 If Yes: 12.c How many months of the pregnancy did you smoke? Months_____

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
13. During this pregnancy did you live with someone who smoked cigarettes, pipes, or cigars at home on a regular basis? Yes......1 No......0	13. During this pregnancy did you live with someone who smoked cigarettes, pipes, or cigars at home on a regular basis? Yes......1 No......0	13. During this pregnancy did you live with someone who smoked cigarettes, pipes, or cigars at home on a regular basis? Yes......1 No......0	13. During this pregnancy did you live with someone who smoked cigarettes, pipes, or cigars at home on a regular basis? Yes......1 No......0	13. During this pregnancy did you live with someone who smoked cigarettes, pipes, or cigars at home on a regular basis? Yes......1 No......0	13. During this pregnancy did you live with someone who smoked cigarettes, pipes, or cigars at home on a regular basis? Yes......1 No......0
14. Did you drink alcoholic beverages around the time that you got pregnant? Yes......1 No......0 **if Yes:** 14.a Did you ever have 5 or more alcoholic drinks at any one time? Yes......1 No......0 14.b Did you stop drinking during this pregnancy? Yes......1 No......0	14. Did you drink alcoholic beverages around the time that you got pregnant? Yes......1 No......0 **if Yes:** 14.a Did you ever have 5 or more alcoholic drinks at any one time? Yes......1 No......0 14.b Did you stop drinking during this pregnancy? Yes......1 No......0	14. Did you drink alcoholic beverages around the time that you got pregnant? Yes......1 No......0 **if Yes:** 14.a Did you ever have 5 or more alcoholic drinks at any one time? Yes......1 No......0 14.b Did you stop drinking during this pregnancy? Yes......1 No......0	14. Did you drink alcoholic beverages around the time that you got pregnant? Yes......1 No......0 **if Yes:** 14.a Did you ever have 5 or more alcoholic drinks at any one time? Yes......1 No......0 14.b Did you stop drinking during this pregnancy? Yes......1 No......0	14. Did you drink alcoholic beverages around the time that you got pregnant? Yes......1 No......0 **if Yes:** 14.a Did you ever have 5 or more alcoholic drinks at any one time? Yes......1 No......0 14.b Did you stop drinking during this pregnancy? Yes......1 No......0	14. Did you drink alcoholic beverages around the time that you got pregnant? Yes......1 No......0 **if Yes:** 14.a Did you ever have 5 or more alcoholic drinks at any one time? Yes......1 No......0 14.b Did you stop drinking during this pregnancy? Yes......1 No......0

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
if YES: 14.c In what month of this pregnancy did you stop drinking? _____ Month #	**if YES:** 14.c In what month of this pregnancy did you stop drinking? _____ Month #	**if YES:** 14.c In what month of this pregnancy did you stop drinking? _____ Month #	**if YES:** 14.c In what month of this pregnancy did you stop drinking? _____ Month #	**if YES:** 14.c In what month of this pregnancy did you stop drinking? _____ Month #	**if YES:** 14.c In what month of this pregnancy did you stop drinking? _____ Month #

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
In the **six months prior to this pregnancy** did you use or become exposed to any of the following at work? 15. **Niles** Tree-marking Paint Yes.....1 No......0 16. **Southern Coatings** Tree-marking Paint Yes.....1 No......0 17. **Nelson** Tree-marking Paint Yes.....1 No......0 18. **Nelson** Boundary/Land Line paint Yes.....1 No......0 19. **Southern Coatings** Boundary/Land Line Paint Yes.....1 No......0 20. Pesticide Application Yes... ...1 No......0 21. Herbicide Application Yes.....1 No......0 22. Assigned to fight forest fires Yes.....1 No......0 23. Assigned to physically strenuous duties Yes.....1 No......0	In the **six months prior to this pregnancy** did you use or become exposed to any of the following at work? 15. **Niles** Tree-marking Paint Yes.....1 No......0 16. **Southern Coatings** Tree-marking Paint Yes.....1 No......0 17. **Nelson** Tree-marking Paint Yes.....1 No......0 18. **Nelson** Boundary/Land Line paint Yes.....1 No......0 19. **Southern Coatings** Boundary/Land Line Paint Yes.....1 No......0 20. Pesticide Application Yes... ...1 No......0 21. Herbicide Application Yes.....1 No......0 22. Assigned to fight forest fires Yes.....1 No......0 23. Assigned to physically strenuous duties	In the **six months prior to this pregnancy** did you use or become exposed to any of the following at work? 15. **Niles** Tree-marking Paint Yes.....1 No......0 16. **Southern Coatings** Tree-marking Paint Yes.....1 No......0 17. **Nelson** Tree-marking Paint Yes.....1 No......0 18. **Nelson** Boundary/Land Line paint Yes.....1 No......0 19. **Southern Coatings** Boundary/Land Line Paint Yes.....1 No......0 20. Pesticide Application Yes... ...1 No......0 21. Herbicide Application Yes.....1 No......0 22. Assigned to fight forest fires Yes.....1 No......0 23. Assigned to physically strenuous duties	In the **six months prior to this pregnancy** did you use or become exposed to any of the following at work? 15. **Niles** Tree-marking Paint Yes.....1 No......0 16. **Southern Coatings** Tree-marking Paint Yes.....1 No......0 17. **Nelson** Tree-marking Paint Yes.....1 No......0 18. **Nelson** Boundary/Land Line paint Yes.....1 No......0 19. **Southern Coatings** Boundary/Land Line Paint Yes.....1 No......0 20. Pesticide Application Yes... ...1 No......0 21. Herbicide Application Yes.....1 No......0 22. Assigned to fight forest fires Yes.....1 No......0 23. Assigned to physically strenuous duties	In the **six months prior to this pregnancy** did you use or become exposed to any of the following at work? 15. **Niles** Tree-marking Paint Yes.....1 No......0 16. **Southern Coatings** Tree-marking Paint Yes.....1 No......0 17. **Nelson** Tree-marking Paint Yes.....1 No......0 18. **Nelson** Boundary/Land Line paint Yes.....1 No......0 19. **Southern Coatings** Boundary/Land Line Paint Yes.....1 No......0 20. Pesticide Application Yes... ...1 No......0 21. Herbicide Application Yes.....1 No......0 22. Assigned to fight forest fires Yes.....1 No......0 23. Assigned to physically strenuous duties	In the **six months prior to this pregnancy** did you use or become exposed to any of the following at work? 15. **Niles** Tree-marking Paint Yes.....1 No......0 16. **Southern Coatings** Tree-marking Paint Yes.....1 No......0 17. **Nelson** Tree-marking Paint Yes.....1 No......0 18. **Nelson** Boundary/Land Line paint Yes.....1 No......0 19. **Southern Coatings** Boundary/Land Line Paint Yes.....1 No......0 20. Pesticide Application Yes... ...1 No......0 21. Herbicide Application Yes.....1 No......0 22. Assigned to fight forest fires Yes.....1 No......0 23. Assigned to physically strenuous duties Yes.....1 No......0

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
Exposures at Home: 24. During this pregnancy was your house or apartment treated with insecticides by a family member or a professional exterminator? Yes.....1 No......0 23. Did YOU ever use or apply chemicals to control pests in either your house or yard during this pregnancy? Yes.....1 No......0 24. Did you paint inside your house or have it painted by someone else during this pregnancy? Yes.....1 No......0 Did you regularly do any of the following activities during this pregnancy? 25. Print making or silk screening? Yes.....1 No......0	**Exposures at Home:** 24. During this pregnancy was your house or apartment treated with insecticides by a family member or a professional exterminator? Yes.....1 No......0 23. Did YOU ever use or apply chemicals to control pests in either your house or yard during this pregnancy? Yes.....1 No......0 24. Did you paint inside your house or have it painted by someone else during this pregnancy? Yes.....1 No......0 Did you regularly do any of the following activities during this pregnancy? 25. Print making or silk screening?	**Exposures at Home:** 24. During this pregnancy was your house or apartment treated with insecticides by a family member or a professional exterminator? Yes.....1 No......0 23. Did YOU ever use or apply chemicals to control pests in either your house or yard during this pregnancy? Yes.....1 No......0 24. Did you paint inside your house or have it painted by someone else during this pregnancy? Yes.....1 No......0 Did you regularly do any of the following activities during this pregnancy? 25. Print making or silk screening? Yes.....1 No......0	**Exposures at Home:** 24. During this pregnancy was your house or apartment treated with insecticides by a family member or a professional exterminator? Yes.....1 No......0 23. Did YOU ever use or apply chemicals to control pests in either your house or yard during this pregnancy? Yes.....1 No......0 24. Did you paint inside your house or have it painted by someone else during this pregnancy? Yes.....1 No......0 Did you regularly do any of the following activities during this pregnancy? 25. Print making or silk screening? Yes.....1 No......0	**Exposures at Home:** 24. During this pregnancy was your house or apartment treated with insecticides by a family member or a professional exterminator? Yes.....1 No......0 23. Did YOU ever use or apply chemicals to control pests in either your house or yard during this pregnancy? Yes.....1 No......0 24. Did you paint inside your house or have it painted by someone else during this pregnancy? Yes.....1 No......0 Did you regularly do any of the following activities during this pregnancy? 25. Print making or silk screening? Yes.....1 No......0	**Exposures at Home:** 24. During this pregnancy was your house or apartment treated with insecticides by a family member or a professional exterminator? Yes.....1 No......0 23. Did YOU ever use or apply chemicals to control pests in either your house or yard during this pregnancy? Yes.....1 No......0 24. Did you paint inside your house or have it painted by someone else during this pregnancy? Yes.....1 No......0 Did you regularly do any of the following activities during this pregnancy? 25. Print making or silk screening? Yes.....1 No......0

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
26. Develop or print photographs? Yes.....1 No......0	26. Develop or print photographs? Yes.....1 No......0	26. Develop or print photographs? Yes.....1 No......0	26. Develop or print photographs? Yes.....1 No......0	26. Develop or print photographs? Yes.....1 No......0	26. Develop or print photographs? Yes.....1 No......0
27. Stained glass or leaded glass artwork? Yes.....1 No......0	27. Stained glass or leaded glass artwork? Yes.....1 No......0	27. Stained glass or leaded glass artwork? Yes.....1 No......0)	27. Stained glass or leaded glass artwork? Yes.....1 No......0	27. Stained glass or leaded glass artwork? Yes.....1 No......0	27. Stained glass or leaded glass artwork? Yes.....1 No......0
28. Oil or acrylic painting? Yes.....1 No......0	28. Oil or acrylic painting? Yes.....1 No......0	28. Oil or acrylic painting? Yes.....1 No......0	28. Oil or acrylic painting? Yes.....1 No......0)	28. Oil or acrylic painting? Yes.....1 No......0	28. Oil or acrylic painting? Yes.....1 No......0
29. Ceramics or Pottery? Yes.....1 No......0	29. Ceramics or Pottery? Yes.....1 No......0	29. Ceramics or Pottery? Yes.....1 No......0	29. Ceramics or Pottery? Yes.....1 No......0	29. Ceramics or Pottery? Yes.....1 No......0	29. Ceramics or Pottery? Yes.....1 No......0
30. Furniture stripping or refinishing? Yes.....1 No......0)	30. Furniture stripping or refinishing? Yes.....1 No......0	30. Furniture stripping or refinishing? Yes.....1 No......0	30. Furniture stripping or refinishing? Yes.....1 No......0	30. Furniture stripping or refinishing? Yes.....1 No......0	30. Furniture stripping or refinishing? Yes.....1 No......0
Pregnancy Outcome					
31. Sex of child: Male. . . . . 1 Female . . . . 2 Multiple birth . . . . 3 Unknown. 4	31. Sex of child: Male. . . . . 1 Female . . . . 2 Multiple birth . . . . 3 Unknown. 4	31. Sex of child: Male. . . . . 1 Female . . . . 2 Multiple birth . . . . 3 Unknown. 4	31. Sex of child: Male. . . . . 1 Female . . . . 2 Multiple birth . . . . 3 Unknown. 4	31. Sex of child: Male. . . . . 1 Female . . . . 2 Multiple birth . . . . 3 Unknown. 4	31. Sex of child: Male. . . . . 1 Female . . . . 2 Multiple birth . . . . 3 Unknown. 4

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
32. Outcome continued: (Circle one number) Full Term (live birth). . .1 **go to section 1** Premature. . . . . 2 **go to section 1** Miscarriage. . . . . 3 **go to section 2** Still Birth . . . . . 4 **go to section 3** Ectopic (tubal). . . . . 5 **if ectopic pregnancy continue with next pregnancy➔** Mole, Molar. . . . . 6 **if molar pregnancy continue with next pregnancy➔** Induced Abortion. . . . . .7 **if induced abortion continue with next pregnancy➔** Other . . . . . 8 _____	32. Outcome continued: (Circle one number) Full Term (live birth). . .1 **go to section 1** Premature. . . . . 2 **go to section 1** Miscarriage. . . . . 3 **go to section 2** Still Birth . . . . . 4 **go to section 3** Ectopic (tubal). . . . . 5 **if ectopic pregnancy continue with next pregnancy➔** Mole, Molar. . . . . 6 **if molar pregnancy continue with next pregnancy➔** Induced Abortion. 7	32. Outcome continued: (Circle one number) Full Term (live birth). . .1 **go to section 1** Premature. . . . . 2 **go to section 1** Miscarriage. . . . . 3 **go to section 2** Still Birth . . . . . 4 **go to section 3** Ectopic (tubal). . . . . 5 **if ectopic pregnancy continue with next pregnancy➔** Mole, Molar. . . . . 6 **if molar pregnancy continue with next pregnancy➔** Induced Abortion. . . . . .7 **if induced abortion continue with next pregnancy➔** Other . . . . . 8 _____	32. Outcome continued: (Circle one number) Full Term (live birth). . .1 **go to section 1** Premature. . . . . 2 **go to section 1** Miscarriage. . . . . 3 **go to section 2** Still Birth . . . . . 4 **go to section 3** Ectopic (tubal). . . . . 5 **if ectopic pregnancy continue with next pregnancy➔** Mole, Molar. . . . . 6 **if molar pregnancy continue with next pregnancy➔** Induced Abortion. . . . . .7 **if induced abortion continue with next pregnancy➔** Other . . . . . 8 _____	32. Outcome continued: (Circle one number) Full Term (live birth). . .1 **go to section 1** Premature. . . . . 2 **go to section 1** Miscarriage. . . . . 3 **go to section 2** Still Birth . . . . . 4 **go to section 3** Ectopic (tubal). . . . . 5 Mole, Molar. . . . . 6 Induced Abortion. . . . . .7 Other . . . . . 8 _____ __ _____

Section 1 Live Births

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
1. Birth Weight: ______ ______ pounds ounces	1. Birth Weight: ______ ______ pounds ounces	1. Birth Weight: ______ ______ pounds ounces	1. Birth Weight: ______ ______ pounds ounces	1. Birth Weight: ______ ______ pounds ounces	1. Birth Weight: ______ ______ pounds ounces
2. According to your practitioner's dates, was the baby born : On the due date? Yes.......0 No.....1 **If Yes skip to Quest. 3** **If NO:** 2.a Early ? Yes.......0 No....1 2.b Late? Yes.......0 No....1 2.c How many weeks early or late? __________ weeks	2. According to your practitioner's dates, was the baby born : On the due date? Yes.......0 No.....1 **If Yes skip to Quest. 3** **If NO:** 2.a Early ? Yes.......0 No....1 2.b Late? Yes.......0 No....1 2.c How many weeks early or late? __________ weeks	2. According to your practitioner's dates, was the baby born : On the due date? Yes.......0 No.....1 **If Yes skip to Quest. 3** **If NO:** 2.a Early ? Yes.......0 No....1 2.b Late? Yes.......0 No....1 2.c How many weeks early or late? __________ weeks	2. According to your practitioner's dates, was the baby born : On the due date? Yes.......0 No.....1 **If Yes skip to Quest. 3** **If NO:** 2.a Early ? Yes.......0 No....1 2.b Late? Yes.......0 No....1 2.c How many weeks early or late? __________ weeks	2. According to your practitioner's dates, was the baby born : On the due date? Yes.......0 No.....1 **If Yes skip to Quest. 3** **If NO:** 2.a Early ? Yes.......0 No....1 2.b Late? Yes.......0 No....1 2.c How many weeks early or late? __________ weeks	2. According to your practitioner's dates, was the baby born : On the due date? Yes.......0 No.....1 **If Yes skip to Quest. 3** **If NO:** 2.a Early ? Yes.......0 No....1 2.b Late? Yes.......0 No....1 2.c How many weeks early or late? __________ weeks

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
2.c **If this pregnancy was early,** were you treated with any of the following methods prior to the baby's birth? 2c1 Medicines by mouth to stop labor? Yes....1 No...0 2c2 Cerclage Yes....1 No....0 2c3 Prolonged bed rest at home? Yes....1 No....0 2c4 Bed rest at the hospital Yes....1 No.....0	2.c **If this pregnancy was early,** were you treated with any of the following methods prior to the baby's birth? 2c1 Medicines by mouth to stop labor? Yes....1 No...0 2c2 Cerclage Yes....1 No....0 2c3 Prolonged bed rest at home? Yes....1 No....0 2c4 Bed rest at the hospital Yes....1 No.....0	2.c **If this pregnancy was early,** were you treated with any of the following methods prior to the baby's birth? 2c1 Medicines by mouth to stop labor? Yes....1 No...0 2c2 Cerclage Yes....1 No....0 2c3 Prolonged bed rest at home? Yes....1 No....0 2c4 Bed rest at the hospital Yes....1 No.....0	2.c **If this pregnancy was early,** were you treated with any of the following methods prior to the baby's birth? 2c1 Medicines by mouth to stop labor? Yes....1 No...0 2c2 Cerclage Yes....1 No....0 2c3 Prolonged bed rest at home? Yes....1 No....0 2c4 Bed rest at the hospital Yes....1 No.....0	2.c **If this pregnancy was early,** were you treated with any of the following methods prior to the baby's birth? 2c1 Medicines by mouth to stop labor? Yes....1 No...0 2c2 Cerclage Yes....1 No....0 2c3 Prolonged bed rest at home? Yes....1 No....0 2c4 Bed rest at the hospital Yes....1 No.....0	2.c **If this pregnancy was early,** were you treated with any of the following methods prior to the baby's birth? 2c1 Medicines by mouth to stop labor? Yes....1 No...0 2c2 Cerclage Yes....1 No....0 2c3 Prolonged bed rest at home? Yes....1 No....0 2c4 Bed rest at the hospital Yes....1 No.....0

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
3. Was your child born with any birth defect that was diagnosed by a doctor at birth? Yes.....1 No....0 if **YES.....** 3.a What type of Birth Defect? __________________ __________________	3. Was your child born with any birth defect that was diagnosed by a doctor at birth? Yes.....1 No....0 if **YES.....** 3.a What type of Birth Defect? __________________ __________________	3. Was your child born with any birth defect that was diagnosed by a doctor at birth? Yes.....1 No....0 if **YES.....** 3.a What type of Birth Defect? __________________ __________________	3. Was your child born with any birth defect that was diagnosed by a doctor at birth? Yes.....1 No....0 if **YES.....** 3.a What type of Birth Defect? __________________ __________________	3. Was your child born with any birth defect that was diagnosed by a doctor at birth? Yes.....1 No....0 if **YES.....** 3.a What type of Birth Defect? __________________ __________________	3. Was your child born with any birth defect that was diagnosed by a doctor at birth? Yes.....1 No....0 if **YES.....** 3.a What type of Birth Defect? __________________ __________________
4. Did a doctor find other birth defects in your child later? Yes.....1 No.....0 if Yes..... 4.a What type of Birth Defect? __________________ __________________ __________________ __________________	4. Did a doctor find other birth defects in your child later? Yes.....1 No.....0 if Yes..... 4.a What type of Birth Defect? __________________ __________________ __________________ __________________	4. Did a doctor find other birth defects in your child later? Yes.....1 No.....0 if Yes..... 4.a What type of Birth Defect? __________________ __________________ __________________ __________________	4. Did a doctor find other birth defects in your child later? Yes.....1 No.....0 if Yes..... 4.a What type of Birth Defect? __________________ __________________ __________________ __________________	4. Did a doctor find other birth defects in your child later? Yes.....1 No.....0 if Yes..... 4.a What type of Birth Defect? __________________ __________________ __________________ __________________	4. Did a doctor find other birth defects in your child later? Yes.....1 No.....0 if Yes..... 4.a What type of Birth Defect? __________________ __________________ __________________ __________________

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
4b What was the child's age when this birth defect was found? ______ ______ Years Months 5. Was your child ever diagnosed with any of the following disabilities: Impaired Vision. . 1 Impaired Hearing. 2 Seizures . . . . 3 Epilepsy. . . . . .4 Cerebral Palsy . . . .5 Ment. Retardation .6 Learning Disability 7 Other. . . . . 8 (specify below) ________________ ________________ 5.a If you marked any of the above, what was the child's age when this condition was diagnosed? ______ ______	4b What was the child's age when this birth defect was found? ______ ______ Years Months 5. Was your child ever diagnosed with any of the following disabilities: Impaired Vision. . 1 Impaired Hearing. 2 Seizures . . . . 3 Epilepsy. . . . . .4 Cerebral Palsy . . . .5 Ment. Retardation .6 Learning Disability 7 Other. . . . . 8 (specify below) ________________ ________________ 5.a If you marked any of the above, what was the child's age when this condition was diagnosed? ______ ______	4b What was the child's age when this birth defect was found? ______ ______ Years Months 5. Was your child ever diagnosed with any of the following disabilities: Impaired Vision. . 1 Impaired Hearing. 2 Seizures . . . . 3 Epilepsy. . . . . .4 Cerebral Palsy . . . .5 Ment. Retardation .6 Learning Disability 7 Other. . . . . 8 (specify below) ________________ ________________ 5.a If you marked any of the above, what was the child's age when this condition was diagnosed? ______ ______	4b What was the child's age when this birth defect was found? ______ ______ Years Months 5. Was your child ever diagnosed with any of the following disabilities: Impaired Vision. . 1 Impaired Hearing. 2 Seizures . . . . 3 Epilepsy. . . . . .4 Cerebral Palsy . . . .5 Ment. Retardation .6 Learning Disability 7 Other. . . . . 8 (specify below) ________________ ________________ 5.a If you marked any of the above, what was the child's age when this condition was diagnosed? ______ ______	4b What was the child's age when this birth defect was found? ______ ______ Years Months 5. Was your child ever diagnosed with any of the following disabilities: Impaired Vision. . 1 Impaired Hearing. 2 Seizures . . . . 3 Epilepsy. . . . . .4 Cerebral Palsy . . . .5 Ment. Retardation .6 Learning Disability 7 Other. . . . . 8 (specify below) ________________ ________________ 5.a If you marked any of the above, what was the child's age when this condition was diagnosed? ______ ______	4b What was the child's age when this birth defect was found? ______ ______ Years Months 5. Was your child ever diagnosed with any of the following disabilities: Impaired Vision. . 1 Impaired Hearing. 2 Seizures . . . . 3 Epilepsy. . . . . .4 Cerebral Palsy . . . .5 Ment. Retardation .6 Learning Disability 7 Other. . . . . 8 (specify below) ________________ ________________ 5.a If you marked any of the above, what was the child's age when this condition was diagnosed? ______ ______

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
6. Is your child living at this time? Yes......1 No......0 **If NO:** 6.a In what month and year did this child die? (example 11 91) _____ ______ Mo. Year 6.b What was the cause of death? (specify) ____________________ ____________________ ____________________ ____________________ ____________________ ____________________	6. Is your child living at this time? Yes......1 No......0 **If NO:** 6.a In what month and year did this child die? (example 11 91) _____ ______ Mo. Year 6.b What was the cause of death? (specify) ____________________ ____________________ ____________________ ____________________ ____________________ ____________________	6. Is your child living at this time? Yes......1 No......0 **If NO:** 6.a In what month and year did this child die? (example 11 91) _____ ______ Mo. Year 6.b What was the cause of death? (specify) ____________________ ____________________ ____________________ ____________________ ____________________ ____________________	6. Is your child living at this time? Yes......1 No......0 **If NO:** 6.a In what month and year did this child die? (example 11 91) _____ ______ Mo. Year 6.b What was the cause of death? (specify) ____________________ ____________________ ____________________ ____________________ ____________________ ____________________	6. Is your child living at this time? Yes......1 No......0 **If NO:** 6.a In what month and year did this child die? (example 11 91) _____ ______ Mo. Year 6.b What was the cause of death? (specify) ____________________ ____________________ ____________________ ____________________ ____________________ ____________________	6. Is your child living at this time? Yes......1 No......0 **If NO:** 6.a In what month and year did this child die? (example 11 91) _____ ______ Mo. Year 6.b What was the cause of death? (specify) ____________________ ____________________ ____________________ ____________________ ____________________ ____________________

Section 2 Miscarriages

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
1. When you miscarried, how many weeks from the end of the last menstrual period were you? ______ Weeks	1. When you miscarried, how many weeks from the end of the last menstrual period were you? ______ Weeks	1. When you miscarried, how many weeks from the end of the last menstrual period were you? ______ Weeks	1. When you miscarried, how many weeks from the end of the last menstrual period were you? ______ Weeks	1. When you miscarried, how many weeks from the end of the last menstrual period were you? ______ Weeks	1. When you miscarried, how many weeks from the end of the last menstrual period were you? ______ Weeks
2. Were there any complication? Yes......1 No.......0 **if Yes:** 2.a What were the complications? (please specify) ______ ______ ______ ______	2. Were there any complication? Yes......1 No.......0 **if Yes:** 2.a What were the complications? (please specify) ______ ______ ______ ______	2. Were there any complication? Yes......1 No.......0 **if Yes:** 2.a What were the complications? (please specify) ______ ______ ______ ______	2. Were there any complication? Yes......1 No.......0 **if Yes:** 2.a What were the complications? (please specify) ______ ______ ______ ______	2. Were there any complication? Yes......1 No.......0 **if Yes:** 2.a What were the complications? (please specify) ______ ______ ______ ______	2. Were there any complication? Yes......1 No.......0 **if Yes:** 2.a What were the complications? (please specify) ______ ______ ______ ______

Section 3 Still Births

First Pregnancy	Second Pregnancy	Third Pregnancy	Fourth Pregnancy	Fifth Pregnancy	Sixth Pregnancy
1. Where did this birth occur? Home. . . . . 1 Hospital. . . . . 2 Other . . . . .3 (specify) __________ __________	1. Where did this birth occur? Home. . . . . 1 Hospital. . . . . 2 Other . . . . .3 (specify) __________ __________	1. Where did this birth occur? Home. . . . . 1 Hospital. . . . . 2 Other . . . . .3 (specify) __________ __________	1. Where did this birth occur? Home. . . . . 1 Hospital. . . . . 2 Other . . . . .3 (specify) __________ __________	1. Where did this birth occur? Home. . . . . 1 Hospital. . . . . 2 Other . . . . .3 (specify) __________ __________	1. Where did this birth occur? Home. . . . . 1 Hospital. . . . . 2 Other . . . . .3 (specify) __________ __________
2. Were you informed of the presence of any birth defects? Yes ......1 No .....0 2.a **If Yes:** please specify the type of birth defect. __________ __________ __________	2. Were you informed of the presence of any birth defects? Yes ......1 No .....0 2.a **if Yes:** please specify the type of birth defect. __________ __________ __________	2. Were you informed of the presence of any birth defects? Yes ......1 No .....0 2.a **If Yes:** please specify the type of birth defect. __________ __________ __________	2. Were you informed of the presence of any birth defects? Yes ......1 No .....0 2.a **If Yes:** please specify the type of birth defect. __________ __________ __________	2. Were you informed of the presence of any birth defects? Yes ......1 No .....0 2.a **If Yes:** please specify the type of birth defect. __________ __________ __________	2. Were you informed of the presence of any birth defects? Yes ......1 No .....0 2.a **If Yes:** please specify the type of birth defect. __________ __________ __________

Comments or room for additional reproductive history:

(Please note the pregnancy, question number, and page to which you are referring)

_____

_____

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_____

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_____

This completes the questionnaire. Thank you for your cooperation and participation. Please return this completed questionnaire in the envelope provided. If you have any questions concerning this questionnaire you may contact the project officer (Richard J. Driscoll, Ph.D.) at (513) 841-4386.

Delivering on the Nation's promise:
Safety and health at work for all people
through research and prevention