

APPENDIX Q HUMAN HEALTH RISK ASSESSMENT

This section describes the potential health and safety hazards associated with manual, mechanical, biological, prescribed fire and herbicide treatments. All of the Alternatives involve risks of exposing workers and the public to these hazards.

1.0 Potential Human Health Effects of Manual and Mechanical Treatment Methods

Manual (hand) and mechanical treatments can present health hazards to forestry workers. Adverse weather and terrain commonly create unfavorable working conditions and increased hazards. Hazards associated with adverse weather conditions include extreme heat and cold, which can be exacerbated by very dry and very wet conditions. Other hazards include: falling objects- especially when cutting trees, tripping or slipping on hazards on the ground; protruding objects such as branches and twigs; poisonous plants and insects, and dangerous wildlife.

Tools and equipment present inherent hazards such as sharp edges on the tools themselves, and the hazardous nature of fuels and lubricants used in mechanized equipment. Manual and mechanical methods present potential ergonomic hazards related to lifting and carrying equipment, and when pulling vegetation.

Injuries can vary from minor cuts, sprains, bruises, and abrasions to major arterial bleeding, compound bone fractures, serious brain concussions, and death. Workers are subject to heat-related illness or hypothermia when working in extreme weather conditions, and may incur musculo-skeletal injuries related to improper body mechanics.

Equipment operators could be injured from improperly operating the equipment or losing control of equipment on steep or slippery terrain. Operators and nearby workers also can suffer hearing damage. Nearby workers and the public can be struck by flying debris around some machinery.

The potential for hazard exposure, i.e. risk of injuries, is exacerbated when workers are fatigued, poorly trained, or poorly supervised, and do not follow established safety practices. Appropriate training, together with monitoring and intervention to correct unsafe practices, would minimize risk of worker injury and illness. Compliance with Occupational Health and Safety Administration (OSHA) standards, along with agency, industry and manufacturers' recommendations reduces the potential exposure and risk of injury to workers. Members of the public are usually not at risk from manual and mechanical methods unless they are too close to machinery that is producing flying debris during treatment.

1.1 Comparison of Alternatives—Exposure to Health Hazards for Workers in Manual Treatments of Invasive Plants

Forest Service accident reports do not identify the type of work being done when an accident occurred, thus data on accidents related to invasive plant treatment is not available. Worker exposure to hazards is the direct effect; exposure varies according to the amount of manual and mechanical treatment projected for each alternative. A quantified relationship between manual treatment acreage and worker exposure, expressed as productivity (time/acre pulled) was determined for a large, multiyear hand pulling project on the Wenatchee National Forest (Henry, 2003). This relationship is applied to EIS alternatives to estimate the number of full-time worker equivalents needed to accomplish annual manual treatments projected for each alternative. No comparable productivity data is available for mechanical treatments.

REF: Henry, Charles. Icicle Road Hand-Pulling Timed Study, in: Techline, Winter 2003-2004. Ag. West Communications, Granby CO.

Hand Pull Plot #1:

$$\text{\$801.00/acre} * 1 \text{ hour} / \text{\$10.09} = 78.64 \text{ hours/acre}$$

Hand Pull Plot #2:

$$\text{\$610.00/acre} * 1 \text{ hour} / \text{\$10.09} = 60 \text{ hours/acre}$$

Average:

$$\text{\$706.00/acre} * 1 \text{ hour} / \text{\$10.09} = 70 \text{ hours/acre}$$

Convert to IPEIS regionwide assumptions:

$$\text{\$340.00 per acre treated} / \text{\$706.00 per acre treated} = 34 \text{ hours per acre} / 70 \text{ hours per acre}$$

Assume 34 worker hours per acre of manual treatment—all alternatives

ALTERNATIVE	ACRES	WORKER HOURS	WORKER DAYS (@ 8 H/DAY)
A	8,610	292,740	36593
B	10,576	359,584	44948
C	7,228	245,752	30719
D	2,024	68,816	8602

2.0 Potential Human Health Effects of Biological Control Treatment Methods

The collection, transport, release and monitoring of biocontrol organisms involves no specific human health hazards except those hazards involved in general field work and vehicle transportation, described under Manual and Mechanical methods, above.

3.0 Potential Human Health Effects of Cultural Treatment Methods

Treatments such as controlled grazing, mulching, and competitive seeding involve no specific human health hazards except those hazards involved in general fieldwork and vehicle transportation, described under Manual and Mechanical methods, above. Fertilization may involve dermal, oral, and inhalation exposures to dusts or liquids containing various chemicals. Fertilizers are not regulated by FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act). Therefore, toxicity testing and hazard identification is not as extensive as for herbicides. The primary nutrient chemicals are identified, and some constituents that have been identified as potentially hazardous by federal or state regulations are also listed. The exposure reduction practices identified in the herbicide treatment health effects analysis could also be applied to fertilizer handling and applications to reduce risk.

4.0 Potential Human Health Effects of Prescribed Burning Treatment Methods

Prescribed burns are associated with hazards from smoke and heat to workers and the public. Hazards to workers range from eye irritation, coughing, and shortness of breath, to severe burns that can leave permanent scars or mortality. Chronic exposure to smoke could lead emphysema or lung cancer. Wood smoke contains polyaromatic hydrocarbons (PAHs), which include at least five chemicals that are carcinogens.

Workers are most at risk of adverse health effects from smoke, but sensitive members of the public may also experience health effects. Prescribed burns may “escape,” control and endanger the public.

To reduce the risks of burn escapes and lingering smoke, the Forest Service has special requirements for planning and implementing prescribed burns. All prescribed burn projects require a Burn Plan, which includes a burning prescription, a description and discussion of fuels, weather, and timing; how to conduct the burn; and safeguards. The safeguards section of the plan addresses all precautions needed to confine the burn to the prescribed area. In addition, the Forest Service has established qualification standards and training requirements for personnel involved in prescribed burning.

5.0 Potential Human Health Effects Related to Herbicide Treatment Methods

The public expressed considerable concern the health risks associated with chemical herbicides. All alternatives allow limited herbicide use but vary by the range of herbicides considered and treatment/restoration standards.

Estimates of potential health risks for each herbicide as proposed for use in each alternative are based on herbicide risk assessments prepared for the Forest Service by Syracuse Environmental Research Associates (SERA). Forest Service/SERA risk assessments use peer-reviewed articles from the open scientific literature and current EPA documents, including Confidential Business Information. Specific methods used in preparing the Forest Service/SERA herbicide risk assessments are described in SERA, 2001. The risk assessment for the adjuvant NPE (nonylphenol polyethoxylate) was conducted and documented by David Bakke, Forest Service Pesticide-Use Specialist, consistent with the assumptions, methodologies, and protocols developed by SERA. The NPE Risk Assessment (Bakke, 2003), was peer-reviewed by SERA toxicologists and other Forest Service and independent experts; it is included in the "Forest Service/SERA herbicide risk assessments" used throughout this EIS.

Only information that is not derived from the relevant Forest Service/SERA Risk Assessments and USDA, 2003 is specifically cited in this section. The risk assessments and associated documentation is available in total in the administrative record for this EIS. Estimates of risk are not absolute; rather, they are relative and based on assumptions and evolving toxicity data. Risk assessments have inherent limitations; these are discussed in Chapter 3.3.2 of the FEIS.

The human health effects from the use of any herbicide depends on the toxic properties (hazards) of that herbicide, the level of exposure to that herbicide at any given time, and the duration of that exposure. The risk to human health from herbicide use can be reduced by reducing exposure through the use of streamside buffer zones, personal protective equipment for applicators, and posting of treated areas. Treatments under all alternatives would be accomplished according to strict safety and health standards.

The following findings apply to herbicides proposed for use in the action alternatives:

- Two herbicides, 2,4-D and triclopyr consistently have the greatest number of invasive plant treatment scenarios where both worker and public health risks exceed EPA target levels (i.e. the RfD's¹). These two herbicides also generate nearly all application scenarios where the Hazard Quotient (HQ) is predicted to be greater than 10 (i.e. expected dose exceeds the RfD by greater than one order of magnitude).
- One herbicide, dicamba, and the adjuvant nonylphenol ethoxylate, have an intermediate number of scenarios where worker and public health risks exceed EPA target levels, and they have a few scenarios where the HQ exceeds 10. Human health risks could generally be mitigated at the project level, but in some limited situations, their use might present significant health risks.
- The remaining nine herbicides rarely and only minimally exceed the RfD's established by EPA. The scenarios that may slightly exceed EPA target levels are only associated with worst-case exposure assumptions and/ or using maximum (rather than typical) application rates, except for exposure to NPE (HQ=5) from drinking spill-contaminated pond water.

5.1 Hazard Analysis

The human health hazards associated with each herbicide active ingredient were evaluated and estimated by a thorough review of available toxicological studies. Possible health effects may include short-term and long-term adverse effects. Short-term effects may include: nausea, headache, dizziness, eye or skin irritation, and coughing. Long-term effects may include: cancer; reproductive, endocrine, immunologic, neurologic effects, and genetic mutations.

The toxicological database for each herbicide was reviewed for acute, subchronic, and chronic effects in laboratory animal studies. Judgments about the potential hazards of herbicides to humans are necessarily based in large part on the results of toxicity tests on laboratory animals. Information on actual human poisoning incidents and effects on human populations supplements the laboratory animal test results, where such information is available. For a background discussion of all toxicological tests and endpoints considered in Forest Service Risk Assessments, refer to SERA, 2001.

¹ See glossary for definition of reference dose.

Toxicity studies were evaluated individually for scientific quality, and cumulatively for all similar studies to identify the NOAEL and Reference Dose (RfD) for each potential effect. Each Forest Service/SERA herbicide risk assessment contains citations for all studies that are reviewed in detail.

Formulated herbicides as applied in Forest Service invasive plant treatments may contain additional compounds besides the active herbicide ingredient that are called impurities or inert ingredients. Other additives, called adjuvants, may be mixed with the diluted formulation before spraying to either enhance the herbicide activity, or to modify undesirable properties of the spray mixture. Additionally, when herbicide formulation chemicals are applied in the environment, they may be transformed into other compounds, called metabolites.

In addition to the analysis of potential hazards to human health from every herbicide active ingredient, Forest Service/SERA risk assessments evaluate any available scientific studies of potential hazards of these other substances associated with herbicide applications: impurities, metabolites, inert ingredients, and adjuvants. There is usually less information available on these substances because they are not subject to the extensive testing that is required for the herbicide active ingredients under FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act). Under FIFRA, inerts are classified into one of four categories, called Lists, based on available toxicity information (see Section 5.1.2). In some cases, inerts and adjuvants are tested to comply with other federal laws, such as the Federal Food, Drug, and Cosmetic Act.

5.1.1 Impurities and Metabolites

Virtually no chemical synthesis yields a totally pure product. Technical grade herbicides contain some impurities. The EPA defines an impurity as "...any substance...in a pesticide² product other than an active ingredient or an inert ingredient, including unreacted starting materials, side reaction products, contaminants, and degradation products" (40 CFR 158.153(d)). Toxicity studies generally account for impurities in the active ingredient, except in the case of carcinogens associated with the following impurities:

- Hexachlorobenzene (HCB) in both clopyralid and picloram.
- Ethylene oxide in NPE (nonylphenol polyethoxylate)-based surfactants.
- 1,4-dioxane in some formulations of glyphosate containing NPE-based surfactants

² References to pesticides in this context also apply to herbicide use.

Analyses of the carcinogenic risk of these three impurities are presented in the corresponding Forest Service/SERA herbicide risk assessments. In addition to the carcinogenic risks, acute and other chronic risks from exposure to HCB are specifically analyzed.

From Bakke, 2003, the risk of cancer from exposure to ethylene oxide in NPE-based surfactants was considered negligible for workers, based on the EPA standard of acceptable risk of less than 1 in 1 million. Ethylene oxide is not analyzed further in this human health risk assessment.

From Borrecco and Neisess 1991, the risk of cancer from exposure to 1,4-dioxane in glyphosate was considered negligible for workers, based on the EPA standard for acceptable risk of less than 1 in 1 million. 1,4-dioxane is not analyzed further in this human health risk assessment.

Similar to impurities, the potential health effects of herbicide metabolites are often accounted for in the available toxicity studies on the herbicide active ingredient, assuming that the toxicological effects of metabolism in the test animal species would be similar to the toxicological effects in humans. Uncertainties in this assumption are encompassed in the precautionary uncertainty factor used in calculating the RfD and may sometimes influence the selection of the study used to derive the RfD.

The herbicide triclopyr presents a special case: its principal metabolite, called TCP, is also a metabolite of chlorpyrifos, an insecticide. The risks for direct, indirect and cumulative effects of human exposure to TCP from both sources are discussed in the Triclopyr herbicide risk assessment (p.3-34).

5.1.2 Inert Ingredients

Forest Service/SERA Risk Assessments analyze the human health risks of inert ingredients and full herbicide formulations by the process described below:

- Compare acute toxicity data between the formulations (that include inert ingredients), and the active ingredients alone to address whether the inert is likely to constitute a substantial fraction of the formulation toxicity;
- Disclose whether or not the formulated products have undergone chronic toxicity testing; and
- Identify, with the help of EPA and the herbicide registrants, ingredients of known toxicological concern in the formulated products and assess the risks of those ingredients.

Researchers who have studied the relationships between acute and chronic toxicity have found that relationships do exist and acute toxicity data can be used to give an indication of overall toxicity (Zeise, et al., 1984). The court in *NCAP v. Lyng*, 844 F.2d 598 (9th Cir 1988) decided that this method of analysis provided sufficient information for a decision maker to make a reasoned decision. In *SRCC v. Robertson*, Civ.No. S-91-217 (E.D. Cal., June 12, 1992) and again in *CATs v. Dombek*, Civ. S-00-2016 (E.D. Cal., Aug 31, 2001) the district court upheld the adequacy of the methodology described above for disclosure of inert ingredients and additives.

The EPA has categorized approximately 1,200 inert ingredients into four lists. Lists 1 and 2 contain inert ingredients of known or suspected toxicological concern. List 4 contains non-toxic substances such as corn oil, honey and water. List 3 includes substances for which EPA has insufficient information to classify as either hazardous (List 1 and 2) or non-toxic (List 4). Use of formulations containing inert ingredients on List 3 and 4 is preferred for invasive plant treatment under current Forest Service policy and in all alternatives considered in the EIS.

Most information about inert ingredients that is submitted to EPA for pesticide registration is classified as “Confidential Business Information” (CBI). CBI is not generally released or available for public review. SERA risk assessors have reviewed the identity and data on inerts in the CBI files when preparing all herbicide risk assessments except 2,4-D. Publicly released information from registrants of herbicides and from Freedom of Information Act requests to EPA has also been reviewed in Forest Service/SERA risk analyses. Comparison of acute toxicity (LD₅₀ values) data between the formulated products (including inert ingredients) and their active ingredients alone shows that the formulated products are frequently less acutely toxic than their active ingredients.

Forest Service/SERA risk assessments review the acute toxicity comparisons, the EPA review, and examine the toxicity information on inert ingredients in each formulated product. For all formulations containing inert ingredients that have been reviewed in the Forest Service/SERA risk assessments, the reviews have concluded that the formulations do not significantly increase the risk to human health and safety over the risks identified for the active ingredients.

5.1.3 Additives

Adjuvants include surfactants, drift reduction agents, and dyes or colorants. Some herbicide formulation labels direct the use of particular adjuvant types when applying the herbicide. Surfactants increase the ability of the herbicide to be absorbed into plant tissues. Dyes and colorants are used to indicate that a plant or area has been treated.

The common risk factors for the use of adjuvants are through skin or eye exposure. Most adjuvants cause various degrees of irritation to skin or eyes. This demonstrates the need for

good industrial hygiene practices when using these chemicals, especially when handling the concentrate, such as during mixing. The use of chemical resistant gloves and goggles, especially while mixing, would greatly reduce exposure to these hazards.

In 2002, the Forest Service reviewed toxicity data for the various types of adjuvants likely to be used in herbicide applications on National Forests (Bakke, 2002). The review found that the surfactant NPE may contain nonylphenol (an EPA List 1 inert), which has potential for toxic effects, including endocrine disruption. Human health risks from exposure to NPE in invasive plant treatments are analyzed in this risk assessment, based on Bakke, 2003.

A colorant often used in foliar applications of these herbicides (Colorfast™ Purple) that contains Basic Violet 3 or Gentian Violet dyes is considered a potential carcinogen. A risk assessment for the carcinogenic properties of this dye was completed (SERA, 1997). The risk assessment found that the cancer risk to workers and the public was considered negligible, based on the EPA standard of acceptable risk of less than 1 in 1 million. For public exposures, the dye would generally reduce exposures both to itself and to the other chemicals it might be mixed with (herbicide and other adjuvants) because the public would be alerted to the presence of treated vegetation. As SERA, 1997 adequately analyzes the health risks of utilizing this dye; it will not be discussed further in this document.

5.2 Dose Response Assessment

To assess human health risks this analysis compares the dose of herbicide received by a worker or a member of the public under each exposure scenario with the corresponding herbicide RfD established by EPA or by the Forest Service/SERA risk assessment for acute and/or chronic exposures. EPA determines a RfD based on the lowest NOAEL for the most sensitive toxic effect that is identified in tests on laboratory animals; then this NOAEL dose is reduced for uncertainties associated with extrapolating animal test data to humans, and for variation in sensitivity among humans. Most frequently, a RfD is 1/100th of the lowest NOAEL, but it may be even lower in some cases. As an example for a hypothetical herbicide, if the lowest acute NOAEL observed in lab animal tests was 1 milligram of chemical per kilogram of body weight (1 mg/kg), the corresponding NOAEL for a 70 kg human would be a dose = 70 mg. The typical RfD for this herbicide would be 0.01 mg/kg, or 0.7 mg dose for a human. Forest Service /SERA risk assessments evaluate all RfD's established by EPA. In specific instances where EPA has not calculated an RfD, or the range of scientific data indicates a rationale for using a more precautionary RfD, FS/SERA establishes the RfD that is used in the risk assessment and EIS. The source and/or rationale for every non-EPA RfD is described in the Dose-response section of the Forest Service/SERA risk assessment. All non-EPA RfD's are identified in Table 5-1.

If doses from all estimated exposures for a specific Forest Service herbicide application are less than the RfD's, the risk of health effects is expected to be minimal. The Forest Service/SERA Risk Assessments describe the basis for the RfD, provide an analysis of the supporting studies, and further refine the risk thresholds for those herbicides with estimated doses that exceed the RfD. Table 5-1 displays the acute and chronic RfDs used in the risk assessment.

Herbicide	Acute RfD	Chronic RfD
2,4-D	0.01*#	0.01*
Chlorsulfuron	0.25#	0.05
Clopyralid	0.75#	0.15
Dicamba	0.10	0.05
Glyphosate	2.0	2.0
Imazapic	0.5#	0.5
Imazapyr	2.5#	2.5
Metsulfuron Methyl	0.25#	0.25
Picloram	0.2#	0.2
Sethoxydim	0.6#	0.09
Sulfometuron Methyl	0.87#	0.02#
Triclopyr	1.0-general population 0.05-women of childbearing age	0.05
Nonylphenol Polyethoxylate	0.1#	0.1#
Hexachlorobenzene	0.008#	0.0008

* U.S. EPA issued a draft RED (Reregistration Eligibility Decision) on 2,4-D for public review on January 12, 2005. The draft RED proposes new RfD's for both acute and chronic toxicity of 2,4-D to humans: acute toxicity to women: 0.025 mg/kg/day; chronic toxicity to all humans: 0.005 mg/kg/day. If EPA's proposed RfD's are applied to all FS/SERA scenarios, **providing the new RED does not cause any other changes to current risk assessment values**, then RED-based acute HQ's would be 0.4x (HQ estimated in EIS); RED-based chronic HQ's would be 2x (HQ estimated in EIS). These potential future revised HQ's would not materially affect the comparison of alternatives in this EIS. The number of scenarios exceeding HQ=1 for 2,4-D applications (Alternative D only) would change from 1 to 0. Other variables used in calculations to estimate HQ in FS/SERA risk assessment scenarios may also change based on the final RED, therefore the extent and magnitude of potential future changes to EIS HQ's cannot be determined at this time. # - These RfD's were not established by EPA; the source and/or rationale for the RfD value that is used is described in the Dose-response section of the corresponding FS/SERA risk assessment.

The herbicides that would be available for use on National Forests under each alternative are compared based on Hazard Quotients (HQ), which is the ratio between the estimated dose (the amount of herbicide received from a particular exposure scenario) and the RfD. When a predicted dose is less than the RfD, then the HQ (dose/RfD) is less than 1, and toxic effects are unlikely for that specific herbicide application.

5.3 Worker and Public Exposure Analysis

Workers and the public may be exposed to herbicides. Workers include applicators, supervisors, and other personnel directly involved in the application of herbicides. The public includes non-project forestry workers, forest visitors or nearby residents who could be exposed through the drift of herbicide spray droplets, through contact with sprayed

vegetation, or by eating, or placing in the mouth, contaminated food items or other plant materials, such as berries or shoots growing in or near forests, by eating game or fish containing herbicide residues, or by drinking water that contains such residues.

5.3.1.1 Worker Exposure Analysis

Herbicide applicators are among the people most likely to be exposed to herbicides. Two types of worker exposure assessments are considered: general and accidental/incidental. General exposure assessment is used to designate those exposures that involve estimates of absorbed dose based on the routine handling of a specified amount of a chemical during each of three application methods (backpack sprayer, ground boom, and aerial). The accidental/incidental exposure scenarios involve specific atypical but plausible events that could occur during any type of application.

The exposure for workers is based on the application rate selected for the herbicide, modified by several operational and human factors: number of hours worked per day, acres treated per hour, and variability in human dermal absorption rates. Rather than focus on a single average value, each of these exposure factors involves a range of values, which when combined create a range of potential exposure rates for any given application rate. This human health risk assessment displays potential risks for each of two application rates: a Forest Service typical rate and the maximum label rate. For each of these application rates, exposures and HQ's are displayed for two values from the potential range of exposures predicted for each herbicide: one typical of the average worker in average working conditions, and a maximum exposure value based on the maximum estimate for every exposure factor that is considered. Thus, this risk assessment presents four potential exposure levels for workers, ranging from the predicted average exposure (typical Forest Service rate-typical exposure variables) to a worst-case predicted exposure (maximum application rate, maximum exposure variables).

For each herbicide, worker HQ's are estimated for typical and maximum rate of application and typical and maximum plausible exposures in the following format.

Herbicide	Typical Rate of Application	Maximum Rate of Application
Herbicide name	Typical Exposure Factors Maximum Exposure Factors	Typical Exposure Factors Maximum Exposure Factors

Although herbicide application involves many different job activities, exposure rates can be defined for three categories: directed foliar applications involving the use of backpacks or similar devices including cut surface and streamline sprays; broadcast hydraulic spray applications; and aerial applications. The two estimated exposure rates (Table 5-2) are based on estimated absorbed doses in workers as well as the amounts of the chemical handled by the

workers (SERA, 1998b). Exposure rates are shown as milligrams of chemical per kilogram of body weight per pound of active ingredient (ai) applied.

Job Category	Typical (mg/kg/lb ai)	Maximum (mg/kg/lb ai)
Ground Application	0.003	0.01
Hydraulic Sprayer	0.0002	0.0009
Aerial Application	0.00003	0.0001

Source: SERA, 1998b, Table 5

Table 5-3 displays the two application rates for each herbicide and the surfactant NPE for which worker and public doses are estimated for the EIS human health risk assessment. The typical rates are the average for each herbicide of recent Forest Service applications nationwide, and closely approximate recent rates used in the PNW Region for four herbicides (dicamba, glyphosate, picloram, and triclopyr) for noxious weed treatment under Alternative A. The maximum application rates are based on the maximum rates specified on each herbicide label for noxious weed treatment. For HCB, the application rate is based on the application rate for picloram and the percentage of HCB in picloram (picloram has the highest level of the HCB impurity of any herbicide considered in this EIS).

Herbicide	App Rate-Typical Lb ai/ac	App Rate-Highest Lb ai/ac
2,4-D	1.0	2.0
Chlorsulfuron	0.056	0.25
Clopyralid	0.35	0.5
Dicamba	0.3	2.0
Glyphosate	2	7
Imazapic	0.1	0.19
Imazapyr	0.45	1.25
Metsulfuron Methyl	0.03	0.15
Picloram	0.35	1.0
Sethoxydim	0.3	0.38
Sulfometuron Methyl	0.045	0.38
Triclopyr	1.0	10
Nonylphenol Polyethoxylate	1.67	6.68
Hexachlorobenzene	0.000004	0.000012

In routine applications, workers may contact and internalize herbicides mainly through the skin, but also through the mouth, eyes or nose. Forest Service/SERA risk assessment

methodology for estimating worker exposures from typical operations encompasses the exposures predicted from multiple routes.

Accidental worker exposures are most likely to involve splashing a solution of herbicides into the eyes or on the skin. Two general types of exposure were modeled: one involving direct contact with a solution of the herbicide and another associated with accidental spills of the herbicide concentrate onto the surface of the skin. For this risk assessment, two exposure scenarios are developed for each of the two types of dermal exposure, and the estimated absorbed dose for each scenario is expressed in units of mg chemical/kg body weight.

Exposure scenarios involving direct contact with herbicide solutions are characterized by immersing unprotected hands for 1 minute or wearing contaminated gloves for 1 hour. While it is unlikely that workers would immerse their hands in herbicide solutions, the contamination of gloves or other clothing is plausible. For these exposure scenarios, the key element is the assumption that wearing gloves saturated with a chemical solution is equivalent to immersing the hands in a solution.

In either case, the concentration of the chemical in solution that is in contact with the surface of the skin and the resulting dermal absorption rate are essentially constant. Exposure scenarios involving chemical spills onto the skin are characterized by a spill onto the lower legs as well as a spill on to the hands. In these scenarios, it is assumed that a solution of the chemical is spilled on to a given surface area of skin and that a certain amount of the chemical adheres to the skin.

5.3.1.2 Worker Risks Related to Occupational Exposures

For typical rate/typical exposure factor applications, workers can apply all twelve herbicides by backpack, ground (boom), and aerial application (where applicable) methods with exposures less than or equal to a HQ of 1 (refer to Table 5-4, 5-5 and 5-6). This indicates that workers can apply these herbicides for long time periods at typical rates without toxic health effects. Only application of 2,4-D by ground boom spray exceeds the HQ threshold of 1 (HQ=2). At typical application rates/ maximum exposure factors, dicamba and triclopyr also exceed the HQ =1 threshold.

For maximum application rates/typical exposure factors, worker exposures result in a HQ greater than 1 for 2,4-D, dicamba, and triclopyr. At maximum application rates/ maximum exposure factors, chlorsulfuron, sulfometuron methyl, also exceed the HQ =1 threshold.

In addition, the cancer risk from all application rates/typical occupational exposures to HCB in picloram or clopyralid are less than the EPA risk threshold standard of 1 chance in 1 million. For maximum application rate/maximum exposures the cancer risk factor from picloram may exceed the EPA standard by 2.

Table 5-4 HQs (non-cancer) for backpack sprayer applicators.		
General (non-accidental) exposures of herbicides, NPE, and the HCB impurity.		
Herbicide	Typical Rate of Application	Maximum Rate of Application
2,4-D	1 8	3 16
Chlorsulfuron	0.04 0.2	0.2 1
Clopyralid	0.03 0.2	0.04 0.3
Dicamba	0.09 0.5	0.6 4
Glyphosate	0.01 0.08	0.05 0.3
Imazapic	0.003 0.02	0.005 0.03
Imazapyr	0.002 0.01	0.007 0.04
Metsulfuron Methyl	0.002 0.01	0.008 0.05
Picloram	0.02 0.1	0.07 0.4
Sethoxydim	0.04 0.3	0.05 0.3
Sulfometuron Methyl	0.03 0.2	0.2 2
Triclopyr	0.3 2	3 16
Nonylphenol Polyethoxylate	0.2 1	0.9 5
Hexachlorobenzene	0.00005 0.0003	0.0001 0.0008
Hexachlorobenzene- CANCER RISK	0.06 0.4	0.2 1

Table 5-5 HQs (non-cancer) for ground broadcast applicators. General (non-accidental) exposures of herbicides, NPE, and the HCB impurity.		
Herbicide	Typical Rate of Application	Maximum Rate of Application
2,4-D	2 15	4 30
Chlorsulfuron	0.06 0.4	0.3 2
Clopyralid	0.03 0.4	0.07 0.5
Dicamba	0.1 1	1 7
Glyphosate	0.02 0.2	0.08 0.5
Imazapic	0.004 0.03	0.009 0.06
Imazapyr	0.004 0.03	0.01 0.08
Metsulfuron Methyl	0.003 0.02	0.01 0.09
Picloram	0.04 0.3	0.1 0.8
Sethoxydim	0.07 0.5	0.09 0.6
Sulfometuron Methyl	0.05 0.3	0.4 3
Triclopyr	0.4 3	4 30
Nonylphenol Polyethoxylate	0.4 3	1 10
Hexachlorobenzene	0.00008 0.0005	0.0002 0.002
Hexachlorobenzene- CANCER RISK	0.1 0.7	0.3 2

Table 5-6 HQs (non-cancer) for aerial applicators.

General (non-accidental) exposures of herbicides, NPE, and the HCB impurity.

Herbicide	Typical Rate of Application	Maximum Rate of Application
2,4-D	1 8	3 16
Chlorsulfuron	0.04 0.2	0.2 1
Clopyralid	0.03 0.2	0.05 0.3
Dicamba	0.1 0.5	0.7 4
Glyphosate	0.01 0.08	0.05 0.03
Imazapic	0.003 0.02	0.006 0.03
Imazapyr	0.003 0.01	0.007 0.04
Metsulfuron Methyl	0.002 0.01	0.009 0.05
Picloram	0.03 0.1	0.07 0.4
Sethoxydim	N/A	N/A
Sulfometuron Methyl	0.03 0.2	0.3 2
Triclopyr	0.3 2	3 16
Nonylphenol Polyethoxylate	0.2 1	1 5
Hexachlorobenzene	0.00005 0.0003	0.0001 0.0008
Hexachlorobenzene- CANCER RISK	0.02 0.4	0.2 1

For triclopyr, the typical application/typical exposure scenarios, both acute and chronic, result in an HQ less than 1. For the typical rate, maximum exposure, the HQ value for chronic (long-term) exposure is 2 (backpack and aerial) to 3 (broadcast). Workers who apply triclopyr only occasionally are unlikely to have any toxic health effects. Given the precautionary nature of the RfD it is unlikely that workers applying triclopyr at typical rates extensively during one or over several seasons could be at risk of toxic effects (impaired kidney function). Triclopyr has been used extensively without reports of acute toxic effects in workers. However, no studies of humans chronically exposed to triclopyr have been conducted to assess the potential for adverse effects on the kidney. Thus, for workers who may apply triclopyr repeatedly at typical rates over a period of several weeks or longer, it is important to ensure that work practices include protective procedures to avoid the maximum potential exposure. For the maximum application rate, typical and maximum exposure, the respective HQ values for chronic (long-term) exposure are 3 and 16 (backpack and aerial) to 4 and 30 (broadcast). Protective procedures to reduce worker exposure become more critical to protect worker health at higher than typical rates.

For NPE, the maximum application rate/typical worker exposure results in HQ's greater than the derived RfD for all application methods (HQ=5, backpack and aerial; =10, broadcast). Given the precautionary nature of the RfD itself, it is unlikely that there would be any signs of toxicity. Nevertheless, under the most precautionary set of dose-response assumptions, workers applying high rates of NPE could be exposed to doses that might cause health effects. If NPE exposure is reduced by using measures described at the beginning of this Risk Characterization section, there is no indication that the workers would be at risk of adverse health effects.

Dicamba produces HQ's for workers for all application methods at the maximum application rate/maximum exposure that are substantially greater than one. For dicamba (HQ=5, backpack and aerial; HQ=10, broadcast), the underlying RfD is based on a gavage exposure, which is likely to show a higher initial internal peak dose than would the same dose in a the real-world situation of skin exposure, where the herbicide would be absorbed much more slowly. With good hygiene practices followed by each individual, actual exposures will not reach the upper ranges of project exposures. Thus, the actual exposures would be below the exposures identified with a concern for potential reproductive effects.

For 2,4-D, typical exposures from typical application rates approximate the RfD and are not of substantial concern. Typical exposures for maximum application rates exceed the HQ slightly at 3. However, exposures from the typical and maximum application rates with maximum exposure assumptions (respective HQ=8 and 16, backpack and aerial; =15 and 30, broadcast) could be associated with adverse effects on organ function or pathology not associated with detectable physical symptoms. This information suggests that 2,4-D can be

applied safely only if project supervisors and individual workers use effective methods to minimize worker exposure.

5.3.1.3 Worker Risks from Accidents and Incidents

Tables 5-7 and 5-8 display the HQs for worker risks from accidents and incidents. For some of the herbicides EPA or FS/SERA have estimated an acute (one-time exposure) RfD. However, in other cases, the HQ is based on the chronic RfD, which estimates risk of health effects from long-term exposure. Accidents/incidents are one-time or rare events, so in these cases, the HQ overestimates potential risk.

All worker accidental exposures at typical and maximum application rate scenarios result in an HQ less than or equal to 1 except for triclopyr. In addition, the cancer risk from all the worker accidental exposures to HCB in picloram or clopyralid are at least 2 orders of magnitude below the risk standard of 1 chance in 1 million.

Table 5-7 shows HQs (non-cancer) for backpack applicators from accidental/incidental exposures at the typical application rate and Table 5-8 shows HQs (non-cancer) for backpack applicators from accidental/incidental exposures at the maximum application rate.

Table 5-7 HQs (non-cancer) for applicators – accidental/incidental exposures – typical application rate.				
Of herbicides, NPE, and the HCB impurity.				
Herbicide	Immersion of hands, 1 min.	Contaminated gloves, 1 hour	Spill on hands, 1 hour	Spill on lower legs, 1 hour
2,4-D	0.003	0.2	0.07	0.2
	0.007	0.4	0.2	0.5
Chlorsulfuron	2E-7	0.00001	0.000007	0.00002
	0.000006	0.0003	0.0003	0.0009
Clopyralid	0.000002	0.0001	0.0003	0.0008
	0.00004	0.002	0.008	0.02
Dicamba	0.00009	0.006	0.002	0.004
	0.0002	0.1	0.04	0.1
Glyphosate	0.000004	0.0002	0.0005	0.001
	0.00003	0.002	0.002	0.006
Imazapic	0.002	0.1	0.001	0.003
	0.007	0.4	0.008	0.02
Imazapyr	0.00002	0.001	0.0002	0.0006
	0.0001	0.006	0.001	0.003

Table 5-7 HQs (non-cancer) for applicators – accidental/incidental exposures – typical application rate.
Of herbicides, NPE, and the HCB impurity.

Herbicide	Immersion of hands, 1 min.	Contaminated gloves, 1 hour	Spill on hands, 1 hour	Spill on lower legs, 1 hour
Metsulfuron Methyl	4 E-8 6E-7	0.000002 0.00003	0.000003 0.0001	0.000008 0.0002
Picloram	0.00008 0.0009	0.005 0.06	0.00009 0.002	0.0002 0.004
Sethoxydim	0.0003 0.0008	0.02 0.05	0.0005 0.002	0.001 0.006
Sulfometuron Methyl	5E-7 0.000003	0.00003 0.0002	0.00001 0.0001	0.00002 0.0003
Triclopyr TEA	0.00002 0.0003	0.001 0.02	0.006 0.09	0.02 0.2
Triclopyr BEE	0.008 0.07	0.5 4	0.02 0.2	0.05 0.4
Nonylphenol Polyethoxylate	0.002 0.004	0.1 0.3	0.0005 0.007	0.001 0.02
Hexachlorobenzene	0.0002 0.004	0.01 0.3	0.000003 0.00008	0.000007 0.0002

Table 5-8 HQs (non-cancer) for applicators – accidental/incidental exposures – maximum application rate
Of herbicides, NPE, and the HCB impurity.

Herbicide	Immersion of hands, 1 min.	Contaminated gloves, 1 hour	Spill on hands, 1 hour	Spill on lower legs, 1 hour
2,4-D	0.006 0.01	0.3 0.8	0.1 0.4	0.3 1
Chlorsulfuron	8E-7 0.00002	0.00005 0.001	0.00003 0.002	0.00008 0.004
Clopyralid	0.000003 0.00005	0.0002 0.003	0.0005 0.01	0.001 0.03
Dicamba	0.0006 0.01	0.04 0.7	0.01 0.3	0.03 0.7
Glyphosate	0.00001 0.0001	0.0008 0.006	0.002 0.008	0.004 0.02
Imazapic	0.003 0.01	0.2 0.8	0.002 0.01	0.006 0.04

Table 5-8 HQs (non-cancer) for applicators – accidental/incidental exposures – maximum application rate				
Of herbicides, NPE, and the HCB impurity.				
Herbicide	Immersion of hands, 1 min.	Contaminated gloves, 1 hour	Spill on hands, 1 hour	Spill on lower legs hour
Imazapyr	0.00007	0.004	0.0006	0.002
	0.0003	0.02	0.003	0.008
Metsulfuron Methyl	2E-7	0.00001	0.00002	0.00004
	0.000003	0.0002	0.0005	0.001
Picloram	0.0002	0.01	0.0003	0.0007
	0.003	0.2	0.004	0.01
Sethoxydim	0.0003	0.02	0.0007	0.002
	0.001	0.06	0.003	0.007
Sulfometuron Methyl	0.000004	0.0002	0.00008	0.0002
	0.00003	0.002	0.001	0.002
Triclopyr TEA	0.0002	0.01	0.06	0.2
	0.03	0.2	0.9	2
Triclopyr BEE	0.08	5	0.2	0.5
	0.7	43	2	4
Nonylphenol Polyethoxylate	0.002	0.1	0.0005	0.001
	0.004	0.3	0.007	0.02
Hexachlorobenzene	0.0006	0.04	0.000008	0.00002
	0.01	0.7	0.0002	0.0005

The accidental typical exposure scenario of wearing gloves contaminated with triclopyr BEE for 1 hour exceeds the RfD (HQ = 5) for maximum rates of application. This indicates that at high application rates, strict adherence to worker hygiene practices is important. Because the RfD and HQ are based on effects from long-term exposure, the likelihood of toxic effects from a one-time exposure is lower than the calculated value.

All of these herbicides can cause irritation and damage to the skin and eyes. Eye or skin irritation is likely to be the only overt effect because of mishandling these herbicides. These effects can be minimized or avoided by prudent industrial hygiene practices during handling. The TEA formulation of triclopyr can have impacts that are more serious to the eyes; eye protection is critical.

5.3.2 Public Exposure Analysis

Under normal conditions, members of the general public should not be exposed to substantial levels of any of these herbicides. Members of the public would generally not be in areas

infested with invasive plants during herbicide application. However, dispersed and developed recreation areas (trailheads, campgrounds, picnic areas, recreation sites, boat ramps, ski areas, work centers, etc) may occur in the vicinity of invasive plant infestations proposed for herbicide treatment. To reduce the likelihood of public exposures in herbicide applications that tier to this EIS, project design criteria will be developed to restrict treatment in and around developed areas and to post treatment areas as needed so that the public may avoid areas where herbicides are being or have recently been applied.

The Forest Service/SERA risk assessments developed two types of public exposure situations called scenarios: acute exposures and longer-term or chronic exposures. Acute exposures assume that a person has contact with the herbicide either during or shortly after an application. Specific scenarios estimate herbicide doses received from direct spray, from dermal contact with sprayed vegetation, or from consumption of contaminated fruit, water or fish. Most of these scenarios model plausible though infrequent application situations. The notable exceptions are the complete coverage of a naked child with herbicide from an accidental overspray, and the accidental spill scenario of a large herbicide tank truck into a small pond with no proper spill response. These two scenarios estimate exposures from a realistic worst-case situation that is highly unlikely to occur in herbicide applications conducted under alternatives in this EIS. Chronic exposure scenarios estimate doses from long-term consumption of fruit, water, or fish following a herbicide application. Detailed summaries of the public exposure scenarios can be found in Forest Service/SERA Risk Assessments.

Estimates of public exposure from contact with direct spray or from different sources of herbicide residues is based on the application rate selected for the herbicide, modified by several operational and human factors such as spray dispersion; interception of spray by vegetation; and variability in human dermal absorption rates. Each of these factors involves a range of values, which when combined create a range of potential exposure rates for any given application rate. This human health risk assessment displays potential risks for each of two application rates: a Forest Service typical rate and the maximum label rate. For each of these application rates, exposures and HQ's are displayed for two values from the potential range of exposures predicted for each herbicide: one typical of the average estimates for each of the exposure factors conditions, and a maximum exposure value based on the maximum estimate for every exposure factor. Thus, this risk assessment presents four potential exposure levels for members of the public, ranging from the predicted average exposure (typical Forest Service application rate-typical exposure variables) to a worst-case predicted exposure (maximum application rate, maximum exposure variables).

For each herbicide, HQ's are estimated for typical and maximum rate of application and typical and maximum plausible exposures in the following format.

Herbicide	Typical Rate of Application	Maximum Rate of Application
Herbicide name	Typical Exposure Factors Maximum Exposure Factors	Typical Exposure Factors Maximum Exposure Factors

5.3.2.1 Direct Spray

Direct spray scenarios assume that a naked child is completely covered with herbicide during a broadcast ground herbicide application. The assumption of 100 percent body coverage with herbicide is much greater than would plausibly happen in a real-world accidental overspray. An additional set of scenarios are included involving a young woman who is accidentally sprayed over the feet and legs.

Table 5-9 displays the HQ values for the public, direct spray scenarios. All public accidental exposures at typical and maximum application rates with typical exposure factors result in an HQ less than or equal to 1 except for 2,4-D and triclopyr. Assuming maximum exposure factors, then dicamba also exceeds the threshold HQ of 1. Cancer risk from these scenarios related to HCB in picloram or clopyralid is not calculated because the risk assessment follows EPA recommendations to measure cancer risk based on average daily dose over a lifetime. Consequently, no attempt is made to quantify risk for an acute, one-time exposure.

Table 5-9 HQ (non-cancer) for the public – direct spray scenarios Of using herbicides, NPE, and the HCB impurity.				
Herbicide	Child, typical rate	Child, maximum rate	Woman, typical rate	Woman, maximum rate
2,4-D	3 8	5 16	0.3 0.8	0.5 2
Chlorsulfuron	0.00007 0.003	0.001 0.06	0.000007 0.0003	0.0001 0.006
Clopyralid	0.01 0.3	0.02 0.4	0.001 0.03	0.002 0.05
Dicamba	0.07 2	0.4 11	0.007 0.2	0.04 1
Glyphosate	0.02 0.09	0.06 0.3	0.002 0.009	0.006 0.03
Imazapic	0.05 0.3	0.09 0.6	0.005 0.03	0.009 0.06
Imazapyr	0.009 0.05	0.02 0.1	0.0009 0.005	0.002 0.01
Metsulfuron Methyl	0.0001 0.004	0.0006 0.02	0.00001 0.0004	0.00006 0.002
Picloram	0.004 0.06	0.01 0.2	0.0004 0.006	0.001 0.02
Sethoxydim	0.02 0.09	0.02 0.1	0.002 0.009	0.003 0.01
Sulfometuron Methyl	0.0004 0.004	0.003 0.04	0.00004 0.0005	0.0003 0.004
Triclopyr TEA	0.2 3	2 35	0.5 7	5 70
Triclopyr BEE	0.7 6	7 57	1 11	14 115
Nonylphenol Polyethoxylate	0.02 0.3	0.02 0.3	0.002 0.03	0.002 0.03
Hexachlorobenzene	0.0001 0.003	0.0003 0.008	0.00001 0.0003	0.00003 0.0008

The direct spray of the naked child with either formulation of triclopyr at the maximum application rates exceeds the HQ level of concern; in this case the HQ was developed for

acute exposures. The direct spray of the woman (feet and legs) also exceeds the corresponding HQ. The Forest Service/SERA triclopyr risk assessment states that all of the dermal exposure assessments are extremely precautionary and designed to identify which possible types of exposure would be most hazardous. Both scenarios illustrate the importance of avoiding public presence during and immediately after spraying triclopyr.

The direct spray of a naked child with 2,4-D at the maximum application rate is predicted to exceed the HQ (23 or 14, depending on formulation). The consequences of accidental exposure are similar to the anticipated consequences of worker exposure, which may cause covert toxic effects but are not likely to cause outward signs of toxicity. For the direct spray at the maximum application rate of a woman, the HQ slightly exceeds a level of concern (HQ=2). The exposure of the woman (0.75 mg/kg) is within the range of variation of the acute RfD (0.75 mg/kg), so health effects as a result of this acute scenario are not expected.

Table 5-9A displays the hazard quotient values for members of the public who might contact sprayed vegetation. The dermal exposure from contaminated vegetation scenario assumes that the herbicide is sprayed at a given application rate and that an individual comes in contact with sprayed vegetation or other contaminated surfaces soon after the spray operation. For these exposure scenarios, some estimates of dislodgeable residue and the rate of transfer from the contaminated vegetation to the surface of the skin must be available. No such data are directly available for these herbicides, and so estimation methods are used.

Table 5-9A HQ (non-cancer) for the public – dermal contact with sprayed vegetation scenario of using herbicides, NPE, and the HCB impurity.		
Herbicide	Typical rate	Maximum rate
2,4-D	0.3 0.9	0.6 2
Chlorsulfuron	0.0002 (0.0001)	0.0004 (0.002)
Clopyralid	0.0007 0.003	0.001 0.005
Dicamba	0.009 (0.03)	0.07 (0.2)
Glyphosate	0.001 (0.003)	0.004 (0.01)
Imazapic	0.001 0.003	0.003 0.005
Imazapyr	0.0005 0.001	0.001 0.004
Metsulfuron Methyl	0.00002 0.0001	0.0001 0.0008
Picloram	0.0006 0.002	0.002 0.005
Sethoxydim	0.001 0.003	0.002 0.004
Sulfometuron Methyl	0.00002 0.0001	0.0002 0.001
Triclopyr TEA	0.6 1	7 16
Triclopyr BEE	1 2	16 21
Nonylphenol Polyethoxylate	0.003 0.04	0.01 0.2
Hexachlorobenzene	0.000005 0.00001	0.00002 0.00003

The scenario involving a woman contacting treated vegetation in all application rate scenarios results in a hazard quotient less than or equal to 1 for all herbicides except 2,4-D at the maximum rate/maximum exposures only, and triclopyr for maximum rates and exposures. In addition, the cancer risk under this scenario from hexachlorobenzene in picloram or clopyralid is at least 5 orders of magnitude below the risk standard of 1 chance in 1 million.

5.3.2.2 Public Exposure from Eating Sprayed Fruit (Acute and Chronic)

In most herbicide treatments for invasive plants, it is very unlikely that humans would eat or place contaminated vegetation in their mouths. However, scenarios could be developed involving either accidental spraying of crops, the spraying of edible wild vegetation, like berries or mushrooms, or the spraying of plants collected by Native Americans for basket weaving or medicinal use. Again, particularly for longer-term scenarios, treated vegetation would probably show signs of damage from herbicide, thereby reducing the likelihood that people would continue to consume it. Still, it is conceivable that individuals could consume contaminated vegetation.

One plausible scenario involves the consumption of contaminated berries after treatment along a road where wild berries grow. This scenario estimates risks from eating other contaminated forest foodstuffs, such as wild mushrooms. The two accidental exposure scenarios developed for this exposure assessment include one scenario for acute exposure and one scenario for longer-term exposure (90 days). In both scenarios, the concentration of herbicide on contaminated vegetation is estimated using a derived empirical relationship between application rate and concentration on vegetation.

Forest Service/SERA risk assessments assume that any contaminant HCB in the applied herbicide does not dissipate or break down over time for the chronic contaminated vegetation scenario. This is due to its long half time in the soil and the BCF in vegetation.

Table 5-10 displays the HQ values from the scenario involving a woman eating sprayed berries (one time) shortly after spraying and eating berries daily for 90 days after they were sprayed. For all herbicides, NPE, and the impurity HCB, HQs are less than or equal to 1 for both the acute and chronic scenario for the typical rates of application with typical exposures. For all the herbicides except 2,4-D and NPE, the HQs are less than 1 for the maximum application rates, typical exposures. Dicamba and triclopyr also exceed HQ=1 for maximum rate, maximum exposure assumptions. In addition, the cancer risk in these scenarios from HCB in picloram or clopyralid is at least 1 order of magnitude below the risk standard of 1 chance in 1 million for all long-term exposure levels.

Table 5-10 HQ (non-cancer) for the public – contaminated fruit while using herbicides, NPE, and the HCB impurity.				
Herbicide	Acute		Chronic	
	Typical rate	Maximum rate	Typical rate	Maximum rate
2,4-D	1 18	2 37	0.3 4	0.5 8
Chlorsulfuron	0.0007 0.01	0.01 0.2	0.0003 0.004	0.06 1
Clopyralid	0.005 0.09	0.008 0.1	0.01 0.2	0.02 0.3
Dicamba	0.04 0.6	0.2 4	0.01 0.2	0.08 1
Glyphosate	0.001 0.003	0.01 0.3	0.002 0.04	0.008 0.1)
Imazapic	0.002 0.04	0.004 0.07	0.0002 0.007	0.0003 0.01
Imazapyr	0.002 0.03	0.006 0.09	0.0008 0.02	0.002 0.05
Metsulfuron methyl	0.001 0.02	0.007 0.1	0.0006 0.009	0.003 0.05
Picloram	0.02 0.3	0.06 0.9	0.003 0.04	0.008 0.1
Sethoxydim	0.006 0.09	0.007 0.1	0.002 0.03	0.002 0.04
Sulfometuron methyl	0.0006 0.01	0.005 0.08	0.004 0.07	0.04 0.6
Triclopyr	0.06 0.7	0.6 7	0.03 0.5	0.3 5
Nonylphenol polyethoxylate	0.2 3	0.8 12	0.003 0.05	0.01 0.2
Hexachlorobenzene	0.000007 0.00006	0.00002 0.0002	0.000003 0.00003	0.000008 0.00007
Hexachlorobenzene- CANCER RISK	N/A	N/A	0.004 0.03	0.01 0.09

5.2.3.4 Water Contamination

Water can be contaminated from runoff, as a result of percolation from contaminated soil, from a direct spill, or from unintentional spray drift from aerial or ground applications. The Forest Service/SERA risk assessments estimate the concentration of each herbicide in water for three scenarios.

There are two acute exposure scenarios. The first assumes that a small child (2- to 3-years old) drinks contaminated water shortly after a large accidental spill of a field herbicide solution into a small pond. The second assumes that a small child drinks stream water contaminated by runoff and/or percolation from an adjacent herbicide-treated area. Because these scenarios are based on the assumption that exposure occurs shortly after the water is contaminated, no dissipation or degradation of the herbicide is considered.

The scenario for chronic exposure to these herbicides from contaminated water assumes that an adult consumes ambient water for a lifetime from a pond contaminated by leaching and/or percolation from an adjacent herbicide-treated area. Except for 2,4-D, all Forest Service/SERA risk assessments use the GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) model to estimate levels of herbicide in ambient water based on the range of herbicide application rates. GLEAMS is a root zone model that can be used to examine the fate and movement of herbicides in soils under different weather and soil conditions. For 2,4-D the projected level of exposure is based on a single forest application monitoring study.

Table 5-11 displays the HQ values from the contaminated water scenarios involving public consumption. These scenarios involving a child drinking from a small pond (0.25 acre) immediately after a spill; a child drinking from a stream after runoff/percolation contamination; and an adult drinking water over a lifetime from a large pond (one acre) contaminated by runoff/percolation. The spill/pond water contamination scenario is an extreme concentration resulting from an accident, not from a treatment activity. It should be considered a worst-case scenario in that it estimates exposures from standing water, with no dilution or decomposition of the herbicide. For the scenario of a child drinking from a stream only 2,4-D slightly exceeds the RfD under typical exposure assumptions. For an adult drinking contaminated pond water over a lifetime, none of the estimated exposures, for any of the herbicides, NPEs, or the impurity HCB, at any application rate, exceeds the RfD (HQ is less than or equal to one). In addition, the cancer risk from HCB in picloram or clopyralid is at least 5 orders of magnitude below the risk standard of 1 chance in 1 million for all chronic contaminated drinking water scenarios.

Table 5-11 HQ (non-cancer) for the public – drinking contaminated water.						
From herbicides, NPE, and the HCB impurity.						
Herbicide	Acute-spill		Acute-stream		Chronic-pond	
	Typical rate	Maximum rate	Typical rate	Maximum rate	Typical rate	Maximum rate
2,4-D	34 51	68 102	1 5	2 9	0.006 0.01	0.01 0.02
Chlorsulfuron	0.006 0.09	0.01 2	0.0004 0.001	0.008 0.02	1E-7 0.000002	0.0002 0.0004
Clopyralid	0.3 2	0.5 3	0.0007 0.004	0.001 0.005	0.0005 0.001	0.0007 0.001
Dicamba	0.8 10	5 68	0.0007 0.003	0.005 0.02	0.000002 0.000007	0.00001 0.00005
Glyphosate	0.7 2	2 7	0.002 0.05	0.005 0.2	0.00003 0.0003	0.0001 0.001
Imazapic	0.2 1	0.4 2	0.000008 0.0002	0.00001 0.0004	1E-7 2E-7	2E-7 4E-7
Imazapyr	0.1 0.4	0.3 1	0.00003 0.002	0.00008 0.005	5E-7 0.000006	0.000001 0.00002
Metsulfuron Methyl	0.02 0.1	0.1 0.7	0.00002 0.0001	0.00009 0.0007	7E-7 0.000002	0.000003 0.000008
Picloram	0.4 3	1 10	0.007 0.04	0.02 0.1	0.00005 0.0002	0.0001 0.0007
Sethoxydim	0.3 0.9	0.4 1	0.008 0.03	0.009 0.04	0.00008 0.0001	0.0001 0.0002
Sulfometuron Methyl	0.03 0.1	0.2 0.9	0.000004 0.0001	0.00003 0.001	0.000003 0.000005	0.00002 0.00005
Triclopyr	0.3 2	3 20	0.007 0.05	0.07 0.5	0.02 0.03	0.2 0.3
Nonylphenol Polyethoxylate	5 7	5 7	0.009 0.04	0.009 0.04	0.002 0.005	0.002 0.005
Hexachlorobenzene	0.00008 0.0007	0.0002 0.002	0.000002 0.00001	0.000007 0.00003	5.E-08 1E-7	1E-7 3E-7
Hexachlorobenzene- CANCER RISK					0.00006 0.0002	0.0002 0.0004

The acute typical exposure scenario with the child drinking water from a spill-contaminated pond estimates that chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, picloram, sethoxydim, sulfometuron methyl, and the impurity HCB have HQ values at or below 1 for all application rates. For the acute typical exposure scenario clopyralid, dicamba, glyphosate, and triclopyr, have HQ values less than or equal to 1 at typical application rates, but exceed a HQ of 1 at maximum application rates. For glyphosate, no effects are expected from an acute HQ that slightly exceeds the chronic RfD. For both dicamba and triclopyr, the accidental spill at the high exposure assumptions scenario exceeds the acute RfD.

The child drinking from a spill-contaminated pond represents the greatest risk for 2,4-D and NPE. For 2,4-D, the HQ of 34 at typical rate and exposures and HQ of 68 at the maximum rate, typical exposures could be associated with adverse effects on organ function or pathology that are not expressed in overt physical symptoms. For NPE, the HQ of 5 for a typical application rate and 7 for maximum rate indicate a risk of effects to the liver and kidney detectable to a physician although these adverse effects may not manifest themselves in symptoms detectable by the exposed child.

Only 2,4-D has HQ's that exceed one for the contaminated stream scenario, and no compound has any scenarios where HQ's exceed one for the long-term consumption of contaminated pond water. These scenarios indicate that 2,4-D is the only compound with any plausible risk to humans consuming water from sources near FS herbicide applications to control invasive plants. FS herbicide applications near domestic use water sources that comply with EIS standards should pose no plausible risks to human health, with the possible exception of 2,4-D without additional mitigations.

5.2.3.5 Fish Consumption

For both the acute and longer-term exposure scenarios involving the consumption of contaminated fish, the water concentrations of the herbicides used are identical to the concentrations used in the contaminated water scenarios. The acute exposure scenario is based on the assumption that an adult angler consumes fish taken from contaminated water shortly after an accidental spill into a pond. No dissipation or degradation is considered. Forest Service/SERA risk assessments make separate acute and chronic exposure estimates of contaminated fish consumption by the general public and by Native American subsistence populations because of documented greater fish consumption by Native Americans.

Some chemicals may be concentrated from contaminated water into the tissues of animals or plants living in water. This process is called bioconcentration. Bioconcentration at first increases with the length of exposure but eventually reaches a constant maximum level. Generally, bioconcentration is measured as the ratio of the maximum concentration in the organism to the concentration in the water, referred to as a bioconcentration factor (BCF). Most of the herbicides in this risk assessment do not bioconcentrate in edible fish tissues; i.e. they have BCF values less than or equal to one. Only chlorsulfuron (BCF=1.5), sethoxydim (BCF=7), sulfometuron methyl (BCF=7), and HCB (BCF=2,000 acute; 20,000 chronic) bioconcentrate in edible fish tissues; the BCF is used in calculating expected doses for consumption of fish from water contaminated with these herbicides.

Tables 5-12 and 5-13 display the HQ values for acute and chronic fish consumption scenarios. For the chronic exposure scenarios, where recreational or subsistence adults consume fish for a lifetime, none of the HQ values exceeds 1. In addition, the cancer risk in these scenarios

from HCB in picloram or clopyralid is at least 1 order of magnitude less than the risk standard of 1 chance in 1 million for all exposure scenarios.

Table 5-12 HQ (non-cancer) for the public –consumption of contaminated fish, acute exposure.

As a result of using herbicides, NPE, and products containing the HCB impurity.

Herbicide	Recreational		Subsistence	
	Typical rate	Maximum rate	Typical rate	Maximum rate
2,4-D	10	20	50	100
	10	20	50	100
Chlorsulfuron	0.0002	0.003	0.0008	0.01
	0.002	0.03	0.008	0.1
Clopyralid	0.01	0.01	0.05	0.07
	0.05	0.07	0.2	0.3
Dicamba	0.02	0.1	0.08	0.5
	0.1	0.9	0.7	4
Glyphosate	0.008	0.03	0.04	0.1
	0.02	0.05	0.08	0.3
Imazapic	0.0008	0.001	0.004	0.007
	0.002	0.004	0.01	0.02
Imazapyr	0.002	0.005	0.009	0.02
	0.004	0.01	0.02	0.05
Metsulfuron Methyl	0.00005	0.0002	0.0002	0.001
	0.0002	0.001	0.0009	0.005
Picloram	0.01	0.03	0.06	0.2
	0.07	0.2	0.3	1
Sethoxydim	0.01	0.01	0.05	0.06
	0.02	0.03	0.1	0.1
Sulfometuron Methyl	0.002	0.02	0.01	0.1
	0.006	0.05	0.03	0.3
Triclopyr	0.0005	0.005	0.002	0.02
	0.002	0.02	0.01	0.1
Nonylphenol Polyethoxylate	0.1	0.3	0.7	0.7
	0.1	0.3	0.7	0.7
Hexachlorobenzene	0.005	0.01	0.02	0.07
	0.03	0.08	0.1	0.4

The acute scenarios show that chlorsulfuron, clopyralid, glyphosate, imazapic, imazapyr, metsulfuron methyl, sethoxydim, picloram, sethoxydim, sulfometuron methyl, triclopyr, NPE, and the impurity HCB have HQ values below 1 for all application rates and for recreational and subsistence populations. In addition, dicamba has HQ values below 1 at all rates for recreational anglers, and for subsistence anglers at typical application rates, but exceeds the HQ (=4) at high application rates.

For 2,4-D, all HQ's are estimated to be many times greater (10 to 100) than the threshold of concern. These exposures could be expected to cause adverse effects on organ function or

pathology that are not expressed in overt physical symptoms; physical symptoms may be manifested in the more highly-exposed subsistence populations.

Table 5-13 shows Hazard Quotients predicted from long-term consumption of contaminated fish. All estimated HQ's are substantially below 1, and no plausible risk of health effects is predicted for consuming fish that have been contaminated with herbicide compounds considered for invasive plant treatment in this EIS.

Table 5-13 HQ (non-cancer) for the public – consumption of contaminated fish, chronic exposure.				
As a result of using herbicides, NPE, and products containing the HCB impurity.				
Herbicide	Recreational		Subsistence	
	Typical rate	Maximum rate	Typical rate	Maximum rate
2,4-D	0.0003	0.0006	0.002	0.005
	0.0006	0.001	0.005	0.009
Chlorsulfuron	7E-9	0.000002	6E-8	0.00001
	1E-8	0.000002	9E-8	0.00002
Clopyralid	0.000002	0.000003	0.00002	0.00003
	0.000004	0.000006	0.00004	0.00005
Dicamba	6E-9	4E-8	5E-8	3E-7
	2E-8	1E-7	2E-7	0.000001
Glyphosate	5E-8	2E-7	4E-7	0.000002
	4E-7	2E-6	0.000004	0.00001
Imazapic	6 E-11	1E-10	5E-10	1E-9
	9E-11	2E-10	8E-10	1E-9
Imazapyr	1E-9	4E-9	1E-8	3E-8
	1E-8	4E-8	1E-7	3E-7
Metsulfuron Methyl	2E-9	1E-8	2E-8	8E-8
	4E-9	2E-8	3E-8	2E-7
Picoloram	3E-7	7E-7	0.000002	0.000006
	0.000001	0.000003	0.000008	0.00002
Sethoxydim	0.000003	0.000003	0.00002	0.00003
	0.000004	0.000005	0.00003	0.00004
Sulfometuron Methyl	5E-8	4E-7	4E-7	0.000003
	8E-8	7E-7	6E-7	0.000005
Triclopyr	0.000005	0.000005	0.00004	0.00004
	0.000009	0.000009	0.00007	0.00007
Nonylphenol Polyethoxylate	0.00001	0.00001	0.00008	0.00008
	0.00002	0.00002	0.0002	0.0002
Hexachlorobenzene	0.000005	0.00001	0.00004	0.0001
	0.00001	0.00003	0.00008	0.0002
Hexachlorobenzene- CANCER RISK	0.006	0.02	0.05	0.1
	0.01	0.04	0.1	0.3

5.4 Sensitive Individuals

The uncertainty factors used in the development of the RfD take into account much of the variation in human response. The uncertainty factor of 10 for sensitive subgroups is sufficient to ensure that most people would experience no toxic effects. “Sensitive” subgroups are those that might respond to a lower dose than average, such as women or children. As stated in National Academy of Sciences (NAS), 1993, the quantitative differences in toxicity between children and adults are usually less than a factor of approximately one order of magnitude (10-fold). Human susceptibility to toxic substances can vary by two to three orders of magnitude, so an uncertainty factor of 10 for sensitive subgroups may not cover every individual that may be unusually sensitive to herbicides. Unusually sensitive individuals may experience effects even when the HQ is equal to or less than 1. Individual susceptibility to the herbicides proposed in this EIS cannot be specifically predicted. Factors affecting individual susceptibility include diet, age, heredity, pre-existing diseases, and life style.

There is anecdotal information (case histories) suggesting that some individuals may be sensitive to 2,4-D. These individuals may develop neuropathy/impaired nerve function after exposure to 2,4-D at levels that are not expected to cause adverse health effects in the general population. The effects reported in the case studies are debilitating, and recovery may be prolonged and incomplete. On the other hand, the case studies do not rule out the possibility that the neuropathy was caused by other unidentified agents.

There is no information to suggest that specific groups or individuals may be especially sensitive to the systemic effects of chlorsulfuron. Though the likely critical effect of chlorsulfuron in humans cannot be defined, the most sensitive effect in laboratory mammals appears to be weight loss. There is also some evidence that chlorsulfuron may alter hematological parameters. It is unclear if individuals with pre-existing diseases of the hematological system or metabolic disorders would be particularly sensitive to chlorsulfuron exposure. Individuals with any severe disease condition could be considered more sensitive to many toxic agents.

There is no information to suggest that specific groups or individuals may be especially sensitive to the systemic effects of clopyralid. The likely critical effect of clopyralid in humans cannot be identified clearly. Clopyralid can cause decreased body weight, increases in kidney and liver weight, decreased red blood cell counts, as well as hyperplasia (an increase in cell numbers) in gastric epithelial tissue. These effects, however, are not consistent among species or even between different studies in the same species. Thus, it is unclear if individuals with pre-existing diseases of the kidney, liver, or blood would be particularly sensitive to clopyralid exposures, although individuals with any severe disease condition could be considered more sensitive to many toxic agents. In addition, some

individuals may suffer from multiple chemical sensitivity, responding adversely to extremely low levels of chemicals and in a manner that is atypical of the general population. There are no data or case reports of such responses to clopyralid.

The only identified sensitive subgroup for dicamba appears to be children. Since the RfD for dicamba explicitly considers the increased sensitivity of children with an additional safety factor and since exposure assessments for children are conducted in the risk assessment, this sensitive subgroup is addressed in the Forest Service/SERA Dicamba risk assessment.

There is no information to suggest that specific groups or individuals may be especially sensitive to the systemic effects of imazapic. Due to the lack of data in humans, the likely critical effect of imazapic in humans cannot be identified clearly. Imazapic exposures have been associated with changes in blood, bone marrow, muscle, and possibly the liver. However, it is unclear if individuals with pre-existing diseases of the hematological system, muscle, or liver would be particularly sensitive to imazapic exposure. Individuals with any severe disease condition could be considered more sensitive to many toxic agents. Given the very low HQs for imazapic, there is no basis for asserting that adverse effects in a specific subgroup are plausible.

There is no information to suggest that specific groups or individuals may be especially sensitive to the systemic effects of imazapyr. Due to the lack of data in humans, the likely critical effect of imazapyr in humans cannot be identified clearly. The mechanism of action for imazapyr is not well understood and imazapyr does not appear to specifically affect the nervous system, immune system, or endocrine function. Given the very low HQs for imazapyr, there appears to be no basis for asserting that an adverse effect in a specific subgroup is plausible. The EPA has judged that infants and children are not likely to be more sensitive to imazapyr than adults. Given the number of studies available on reproductive and developmental effects and the unremarkable findings from these studies, this judgment appears appropriate.

There is no information to suggest that specific groups or individuals may be especially sensitive to the systemic effects of metsulfuron methyl. Due to the lack of data in humans, the likely critical effect of metsulfuron methyl in humans cannot be identified clearly. In animals the most sensitive effect of metsulfuron methyl appears to be weight loss. However, there is some suggestion that metsulfuron methyl may influence blood glucose levels and cholesterol regulation. If exposure levels were sufficient to induce decreases in serum glucose, individuals taking medication to lower serum glucose could be at increased risk. Nonetheless, this exposure scenario is highly implausible.

There is no information to suggest that specific groups or individuals may be especially sensitive to the systemic effects of picloram. The likely critical effect of picloram in humans

cannot be identified clearly. In animals, the most sensitive effect of picloram involves changes in the staining characteristics of liver cells. These effects, however, were only noted in one study and are not consistent among species or even between different studies in the same species. Thus, it is unclear if individuals with pre-existing diseases of the liver would be particularly sensitive to picloram exposures, although individuals with any severe disease condition could be considered more sensitive to many toxic agents.

There is no information to assess whether or not specific groups or individuals may be especially sensitive to the systemic effects of sethoxydim. The mechanism of the acute and chronic toxicity of sethoxydim is unclear but may be related to the ability of sethoxydim to uncouple oxidative phosphorylation. Other effects noted in experimental mammals include decreases in food consumption as well as decreased body weight and the occurrence of liver pathology.

There is no information to suggest that specific groups or individuals may be especially sensitive to the systemic effects of sulfometuron methyl. Due to the lack of data in humans, the likely critical effect of sulfometuron methyl in humans cannot be identified clearly. The most sensitive effect reported in animals for chronic sulfometuron methyl exposure appears to involve changes in blood that are consistent with hemolytic anemia. Thus, individuals with pre-existing anemia could potentially be at an increased risk. Sulfometuron methyl appears to have the potential to alter thyroid gland function. Individuals with pre-existing thyroid dysfunction may, therefore, be at increased risk. However, there are no data to support directly support these speculations.

Because triclopyr may impair blood filtration, individuals with pre-existing kidney diseases are likely to be at increased risk. Women of childbearing age have been recognized by EPA as a particularly sensitive subgroup for acute exposures to triclopyr by reducing the RfD from 1.0 mg/kg/day to 0.05 mg/kg/day.

There is limited information to suggest that specific groups or individuals may be especially sensitive to the systemic effects of NPE-based surfactants. NPE can cause increases in kidney and liver weight, and effects to kidney function and structure. Thus, individuals with pre-existing conditions that involve impairments of the kidney or liver may be more sensitive to this compound. There is some indication that sensitive individuals may develop contact allergies. People with a history of skin allergic reactions to soaps and detergents may be especially sensitive to dermal exposures of NPE-based surfactants.

The potential of NPE to induce reproductive effects should be considered low. Based on the available dose/duration/severity data, it appears that exposure levels below those associated with the most sensitive effect (i.e., kidney effects) are not likely to be associated with reproductive toxicity. However, as shown in the exposure scenarios, there is the potential for

acute exposures to be in the range (considering a 100X safety factor) where effects to the developing fetus may occur, therefore pregnant women could be considered a sensitive population.

5.5 Cumulative Effects

5.5.1 Additive or Synergistic Effects from Herbicide Mixtures

Synergistic effects (multiplicative) are those effects resulting from exposure to a combination of two or more chemicals that are greater than the sum of the effects of each chemical alone (additive). Instances of chemical combinations that cause synergistic effects are relatively rare. Reviews of the scientific literature on toxicological effects and toxicological interactions of agricultural chemicals indicate that exposure to a mixture of pesticides is more likely to lead to additive rather than synergistic effects (US EPA, 2000; ATSDR, 2004). The literature review by the Agency for Toxic Substances and Disease Registry, U.S. Public Health Service cited several studies that found no synergistic effects for mixtures of four, eight, and nine chemicals at low (sub-toxic) doses.

Nonetheless, statistically significant interactions (both synergistic and antagonistic) have been noted in some studies. Even with excellent data, the complexity of the experimental designs necessary to properly assess interactions and the uncertainties regarding the dose-response relationship for interactions the risk characterization for chemical mixtures uncertain.

The guidance resulting from the reviews and analyses of available information by both EPA and ATSDR is that synergistic effects are implausible for human exposures to chemical mixtures where the dose from each chemical is at least one order of magnitude below its respective RfD (i.e. $HQ < 0.1$), and the sum of individual HQ's does not approach an additive $HQ=1$.

The combination of surfactant and herbicide might indicate an increased rate of absorption through the skin; however, a review of recent studies indicates this is not likely to be true (Bakke, 2002). For a surfactant to increase the absorption of another compound, the surfactant must affect the maximum layer of the skin. Without some physical effect to the skin, there would be no change in absorption as compared to the other compound alone. The studies indicate that in general non-ionic surfactants have less of an effect on the skin, and hence absorption, than anionic or cationic surfactants. Compound specific studies indicate that the alkylphenol ethoxylates generally have little or no effect on absorption of other compounds. In several studies, the addition of a surfactant actually decreased the absorption through the skin. It would appear that there is little support for the contention that the addition of surfactants to herbicide mixtures would increase the absorption through the skin of these herbicides.

Several of the herbicides considered in this EIS can be combined with other herbicides to increase the range of effective control. Studies of these twelve herbicides in combination with other compounds are not common, as toxicology studies generally involve the active ingredient. So to the extent that any studies exist, they are important to consider for their insight into potential impacts of combinations.

2,4-D may be applied with most of the herbicides considered in this EIS. A commercial formulation of picloram and 2,4-D, known as Tordon 202C, has been shown to inhibit immune response in mice and to cause birth defects and death in offspring of male mice that were exposed. A commercial formulation of picloram and 2,4-D, Tordon 202C, has been shown to inhibit immune function in mice. The design of this study does not permit the determination of which agent caused the immune response or whether the immune response was attributable to a toxicologic interaction of the two herbicides. No data have been encountered in the literature that permits a characterization of the joint action of either 2,4-D or picloram (i.e., synergism, antagonism, or additivity) with any of the other herbicides considered in this EIS.

The manufacturers recommend that chlorsulfuron formulations be mixed with a non-ionic surfactant. There is no information available to assess the toxicological effects or risks of chlorsulfuron mixed with a surfactant. Telar may be applied in combination with other herbicides including 2,4-D or glyphosate. No data have been encountered in the literature that permits a characterization of the joint action of chlorsulfuron (i.e., synergism, antagonism, or additivity) with most herbicides.

Clopyralid may be applied in combination with other herbicides, particularly in combination with 2,4-D or 2,4-D and picloram. No data have been encountered in the literature that permits a characterization of the joint action of clopyralid (i.e., synergism, antagonism, or additivity) with most herbicides.

Dicamba is labeled for mixing with all other considered herbicides except imazapic and sethoxydim. There is no substantial evidence that dicamba would interact with other compounds. As discussed in the Forest Service/SERA dicamba risk assessment, one study indicates that dicamba does not induce cytochrome P-450 activity and does not substantially affect a variety of other xenobiotic metabolizing enzymes. Although this finding does not rule out the possibility that dicamba may be involved in toxicologically significant interactions, the induction of cytochrome P-450 is a major mechanism by which such interactions are known to occur.

Little information is available about the interaction of glyphosate with other compounds. The available data do not suggest a synergistic interaction between glyphosate and the ethoxylated

tallow amine (POEA) surfactant used in several formulations of glyphosate from plausible routes of exposure.

The manufacturer of imazapic has recommended tank mixtures of this herbicide with glyphosate. No data are available on the combined toxicity of these two herbicides. Studies have been conducted on mixtures of 2,4-D and imazapic. While these combinations are more toxic than imazapic alone, there appears to be no basis for asserting that synergistic effects are likely because the toxic action is probably due to 2,4-D

Imazapyr may be applied in combination other herbicides. Imazapyr is often applied in combination with triclopyr and is occasionally applied in combination with the herbicide fosamine ammonium. No data have been encountered in the literature that permits a characterization of the joint action of imazapyr (i.e., synergism, antagonism, or additivity) with most herbicides. The limited information encountered in the EPA files on mixtures of imazapyr with the herbicide imazethapyr does not indicate any substantial interaction.

The manufacturers recommend that metsulfuron methyl formulations be mixed with a surfactant. There is no published literature or information in the FIFRA files that would permit an assessment of toxicological effects or risks of metsulfuron methyl mixed with a surfactant. According to the product label, Escort may be applied in combination with other herbicides. No data have been encountered in the literature that permits a characterization of the joint action of metsulfuron methyl (i.e., synergism, antagonism, or additivity) with other herbicides considered in this EIS.

Sethoxydim can be applied with other herbicides; no data are available on the combined toxicity of sethoxydim with other pesticides. Poast does contain a petroleum solvent as well as a polyoxyethylene nonylphenol emulsifier. While these agents have a substantial impact on the ecological risk assessment, there is no information suggesting that these agents have a substantial impact on the toxicity of sethoxydim to humans or experimental mammals.

The manufacturers recommend that sulfometuron methyl formulations be mixed with a surfactant. There is no published literature or information in the FIFRA files that would permit an assessment of toxicological effects or risks of sulfometuron methyl mixed with a surfactant. According to the product label, Oust may be applied in combination with other herbicides particularly glyphosate, imazapyr, hexazinone. No data have been encountered in the literature that permits a characterization of the joint action of sulfometuron methyl (i.e., synergism, antagonism, or additivity) with other herbicides considered in this EIS.

There is very little information available on the interaction of triclopyr with other compounds. The available data do not suggest a synergistic interaction between the triclopyr active ingredient and the other components in the commercial triclopyr formulations of Garlon 3A or Garlon 4. No data have been encountered in the literature that permits a characterization of

the joint action of triclopyr (i.e., synergism, antagonism, or additivity) with other herbicides considered in this EIS.

Estrogenic effects (a common toxic action, and a form of endocrine disruption) can be caused by additive amounts of nonylphenol (NP), NPE, and their breakdown products. In other words, an effect could arise from the additive dose of a number of different xenoestrogens (estrogens from outside the body), none of which individually have high enough concentrations to cause effects. This can also extend out to other xenoestrogens that biologically react the same. Additive effects, rather than synergistic effects, are expected from combinations of these various estrogenic substances (Bakke, 2003).

5.5.2 Risks of Potential Cumulative Human Health Effects from Herbicides Considered for Use

The proposed use of herbicides could result in cumulative doses of herbicides to workers or the general public. Cumulative doses to the same herbicide result from (1) additive doses via various routes of exposure resulting from a single invasive plant treatment project and (2) additive doses if an individual is exposed to other herbicide treatments. Additional sources of exposure include: use of herbicides on adjacent private lands or home use by a worker or member of the general public.

This risk assessment specifically considers the effect of repeated exposure in the chronic exposure scenarios and the use of the chronic RfD as an index of acceptable exposure. Consequently, repeated exposure to levels below the toxic threshold should not be associated with cumulative toxic effects.

Each of the HQs discussed in previous sections involves a single exposure scenario. Where individuals could be exposed by more than one route, the cumulative risk of such cases can be quantitatively characterized by adding the HQs for each exposure scenario. Using glyphosate as an example, the typical levels of exposure for a woman being directly sprayed on the lower legs, staying in contact with contaminated vegetation, eating contaminated fruit, and consuming contaminated fish leads to a combined (acute) HQ of 0.012. Similarly, for all of the chronic glyphosate exposure scenarios, the addition of all possible pathways lead to HQs that are two orders of magnitude less than 1, indicating an acceptable level of cumulative risk. Similar scenarios can be developed with the other herbicides.

Since these herbicides persist in the environment for a relatively short time (generally less than 1 year), do not bioaccumulate in humans, and are rapidly eliminated from the body, no cumulative effects from retreatments in subsequent years are predicted.

Cumulative effects can be caused by different chemicals with a common metabolite or a common toxic action. With the exception of triclopyr and chlorpyrifos discussed below, none

of the other herbicides have been demonstrated to share a common metabolite with other compounds. There is no evidence that any of the herbicides share a common toxic action with any other compound including other pesticides.

The primary environmental metabolite of triclopyr is TCP. TCP is also the primary metabolite of an insecticide called chlorpyrifos. Cumulative doses of TCP could result from additive doses resulting from triclopyr and chlorpyrifos use. Although chlorpyrifos is not generally used in forestry, recent studies have shown drift of chlorpyrifos, and other insecticides, from agricultural lands in the Sacramento/San Joaquin Valley to the Sierra Nevada range. Levels of chlorpyrifos have been measured in watercourses in the Sierra Nevada as high as 0.000013 mg/L. It is unlikely that such high aquatic levels of chlorpyrifos would be found in the EIS area as a result of atmospheric movement because, compared to the previous study area, the surrounding lands in Oregon and Washington have higher rainfall levels and less extensive area of intensive crop cultivation. However, assuming that 10 percent of the applied triclopyr under the typical rate of application could degrade to TCP, and using the pond spill scenario, the amount of TCP from triclopyr would be 0.36 mg/L. Assuming that 100 percent of the chlorpyrifos would degrade to TCP (an over-exaggeration of the rate of degradation), this would add 0.000013 mg/L of TCP, resulting in no appreciable increase in risk.

Estrogenic effects (a common toxic action, and a form of endocrine disruption) can be caused by additive amounts of nonylphenol (NP), NPE, and their breakdown products. In other words, an effect could arise from the additive dose of a number of different xenoestrogens (estrogens from outside the body), none of which individually have high enough concentrations to cause effects. This can also extend out to other xenoestrogens that biologically react the same. Additive effects, rather than synergistic effects, are expected from combinations of these various estrogenic substances.

When assessing cumulative effects of exposure to NP and NPE, there must be some consideration of the contribution from other sources, such as personal care products (skin moisturizers, makeup, deodorants, perfumes, spermicides), detergents and soaps, foods, and from the environment away from the forest herbicide application site. In addition to xenoestrogens, humans are exposed to various phytoestrogens, which are hormone-mimicking substances naturally present in plants. In all, more than 300 species of plants in more than 16 families are known to contain estrogenic substances, including beets, soybeans, rye grass, wheat, alfalfa, clover, apples, and cherries.

The Forest Service, Pacific Southwest Region recently analyzed the risks of cumulative estrogenic effects from proposed Forest Service use of NPE, plus worst-case environmental background and consumer product exposures (USDA, 2002). Adding together the cumulative contributions from the worst-case background environment and consumer products, the risk

assessment estimated that backpack applicator exposure would add from 0.1 (typical rate) to 10 (maximum rate) to the cumulative HQ, which ranged from 3 (low dermal exposure assumptions) to 270 (high dermal exposure assumptions). For the public chronic exposures at the maximum application rate, the doses of NPE would add 0.00002 to 0.2 to any HQ. These may be negligible depending upon the background exposures, lifestyles, absorption rates, and other potential chemical exposures that are used to determine overall risk to environmental xenoestrogens.

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