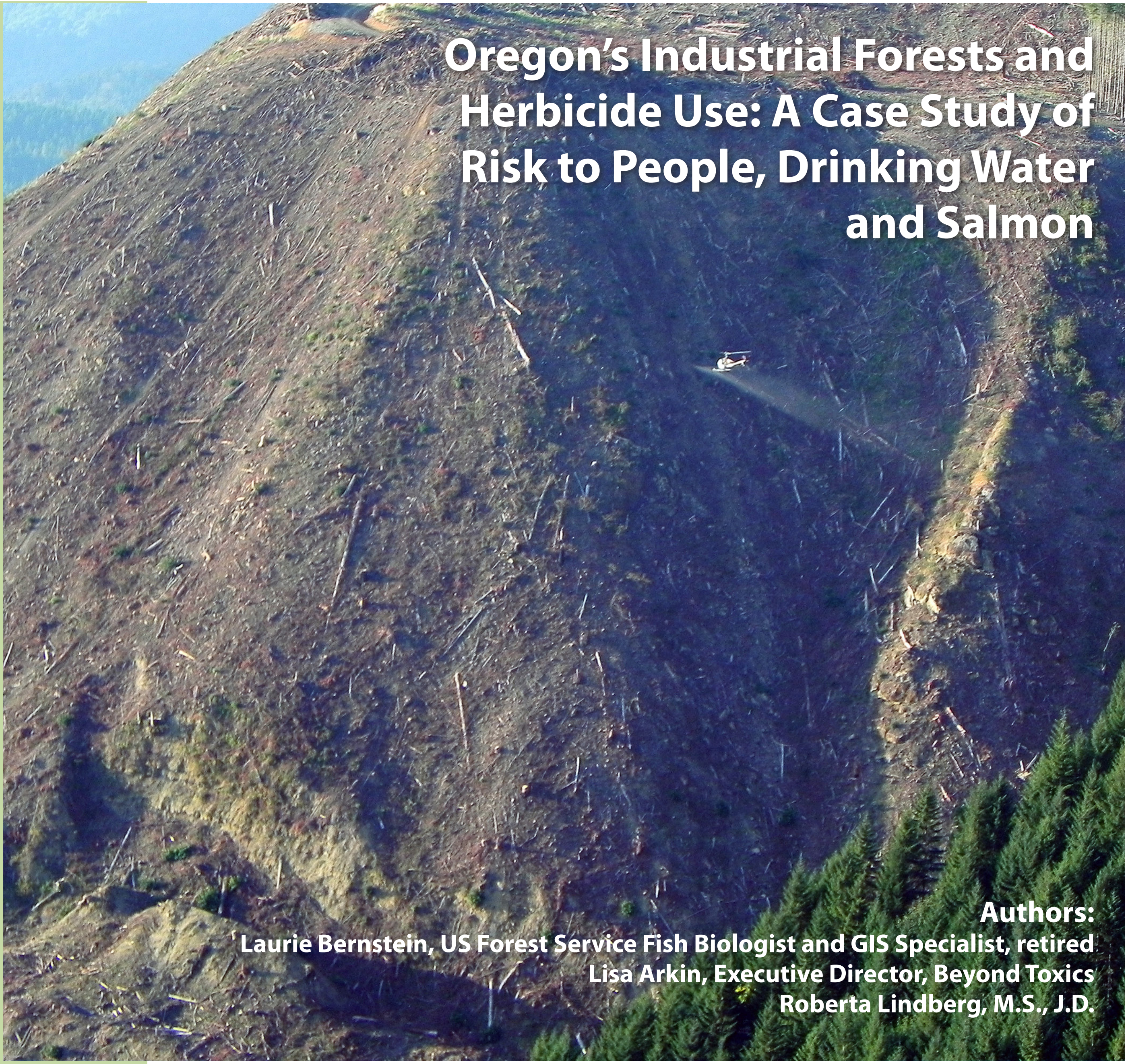

Oregon's Industrial Forests and Herbicide Use: A Case Study of Risk to People, Drinking Water and Salmon

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a BEYOND TOXICS report

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Cover photos
Top: Triangle Lake in the Siuslaw Watershed. Photograph by Gary Hale.
Bottom: Helicopter spraying herbicides on an Oregon clearcut. Photograph by Francis Eatherington.

BEYOND TOXICS
Leadership For a Clean and Just Oregon

Mission Statement
Beyond Toxics is a statewide organization working for all Oregonians to expose root causes of toxic pollution and help communities find solutions that protect human and environmental health.

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Oregon's Industrial Forests and Herbicide Use:
A Case Study of Risk to People, Drinking Water and Salmon

Executive Summary

Oregon's Industrial Forests and Herbicide Use: A Case Study of Risk to People, Drinking Water and Salmon is the first in-depth analysis of industrial forestry pesticide application records for the State of Oregon. This report provides GIS mapping and quantitative measurements derived from herbicide forestry spray records from Lane County, Oregon to document and discuss three primary concerns:

1) The Oregon Forest Practices Act lacks adequate protections for human health, surface and ground water, and the future survival of protected fish species.
2) Chemical application rules of the Oregon Forest Practices Act fail to fulfill legal responsibilities compared to regulations in the neighboring states of Washington and Idaho, states with similar forest ecosystems.
3) The Oregon Forest Practices Act prohibits other state agencies, researchers, medical professionals and the public from getting accurate information about what types and quantities of herbicides are sprayed. Lack of information increases the potential for health and environmental risks due to the absence of regulations for buffer zones around homes, schools, towns, drinking water, and the headwaters of rivers.

Recommendations

The report concludes with recommendations for modernizing the Oregon Forest Practices Act.

- The State should make the Oregon Forest Practices Act equal to or more effective than the Washington Forest Practices Act.
- Make all forest operations, including chemical application documents, available through a publicly accessible website similar to Washington's Forest Practices Application Review System (FPARS).
- Provide the Oregon Department of Forestry, in consultation with the Oregon Department of Environmental Quality, the authority to review, comment, and require modifications of forest vegetation management written plans based on an environmental and human health assessment and proof of compliance with state and federal laws. Require written plans to be made available for public review and comment.
- Comply with ORS 629-035-0030 subsection 3(B), to protect all surface waters.

Background

The *Case Study of Risk to People, Drinking Water and Salmon* provides information regarding the use of herbicides on 184,320 acres of private industrial and state forestlands surrounding Triangle Lake, a rural area in western Lane County, Oregon.

In 2011, following complaints from rural residents about health problems that coincided with forestry aerial herbicide sprays, state and federal agencies launched the Highway 36 Corridor Public Health Exposure Investigation. The investigation resulted in the Oregon State Forester requiring pesticide applicators to turn over three years of forestry pesticide spray records from private and state timber operations (2009-2011).

Studying the spray records gathered during the Health Exposure Investigation provided new data, and a first-time review and analysis of industrial forestry herbicide practices.

This report raises public awareness and informs policy decisions about the associated risks of a common industrial forestry practice – aerially spraying herbicides over hundreds of thousands of forest and riparian acres.

Findings

- The chemical regulations of the Oregon Forest Practices Act are weaker than regulations in Washington and Idaho. Unlike these neighboring states, in Oregon there are:
  - no spray buffers around homes, schools and farms
  - smaller spray buffers along fish-bearing streams
  - no protections for non-fish surface waters, including headwaters of streams
  - minimal protection of drinking water
  - no protection of ground water, including where ground water filters through to drinking water sources
  - no restrictions of pesticides known to contaminate ground water or prone to drift in air

- Pesticide applicators mix their own “chemical soups,” or tank mixes, of herbicides that contain two to five active ingredients and adjuvant products, despite a lack of understanding about synergistic effects of multiple chemicals combined and released into the environment.

- The data show increasing acres of aerial sprays applications and increasing pounds of pesticides applied per acre over the three-year period.

- Atrazine and 2,4-D were detected in urine samples of rural residents in 2011, in the same year that:
  - o the pounds of 2,4-D applied by aerial spray increased by 80%
  - o the pounds of atrazine applied by aerial spray increased by 73%

- Types of herbicides widely used in forestry were detected in threatened coastal Coho salmon habitat streams and in the Triangle Lake School's drinking water.

- Aerial herbicide sprays occur:
  - o directly over headwaters of protected salmon streams
  - o within 60 feet of threatened Coho salmon streams

Comparing the chemical regulations between Washington and Oregon revealed glaring differences in agency jurisdiction:

- Oregon state agencies have no authority to critique and require modifications of forestry herbicide applications.
- In Oregon, there is no public process to know about or make comment on timing, location and types of herbicides used; there are considerable financial and procedural barriers to public involvement.
- The Oregon Forest Practices Act prohibits doctors, the public or researchers from obtaining timely access to herbicide spray records.

Conclusion

Based on the assessment of herbicide application data, the report concludes the Oregon Forest Practices Act is inadequate to protect human health, drinking water and all surface water. It fails to assure agency oversight, fails to make environmental compliance transparent, and fails to require best management practices based on current science.

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Introduction

Many private forest landowners in Oregon, both large industrial companies and small forestland operations, choose to use herbicides to control unwanted vegetation that might compete with tree seedlings. Herbicides, a type of pesticide formulated to kill plants, are viewed as the most cost-effective means of achieving their reforestation goals[1]. Other methods for controlling unwanted vegetation include cutting of brush by hand or with power tools (Oregon Department of Forestry, website). The U.S. Forest Service and the Bureau of Land Management (BLM), both of which manage land throughout Oregon, practice these mechanical methods.

Controversy over pesticides on industrial[2] forestland has existed in rural communities throughout western Oregon since the 1970s. In 1979, the U.S. Environmental Protection Agency (EPA) banned the use of the herbicide 2,4,5-T, one of two chemicals in Agent Orange (the other is 2,4-D, still used by private timber companies). Oregon was a testing site for Agent Orange and the ban was enacted following reports of widespread health effects, particularly miscarriages, in the Siuslaw and Alsea basins of western Oregon. Recognizing these health risks, the routine use of pesticides including all aerial herbicide spraying by BLM and the U.S. Forest Service in Oregon ceased in 1984.

Throughout the following decades, forestry aerial spray of pesticides continued to generate public concern and health complaints. In 2012 federal and state agencies initiated a pesticide exposure investigation in Triangle Lake and surrounding areas located in western Lane County, Oregon (Oregon Health Authority, 2013). This investigation was undertaken in response to local residents filing numerous written and verbal health complaints to the Oregon Department of Forestry, the Oregon Board of Forestry, the Oregon Department of Agriculture and the Governor, as well as to the U.S. EPA.

Oregon's Industrial Forests and Herbicide Use: A Case Study of Risk to People, Drinking Water and Salmon analyzes industrial forestry herbicide use in Oregon using data from the Triangle Lake exposure investigation. The case study is limited

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[1] In this report the term herbicide, pesticide and chemical are used interchangeably with the understanding that the data in this report refers to herbicide applications only. Other types of pesticides include insecticides, rodenticides, miticides, fungicides, bactericides, etc.

[2] For purposes of this report, the term "industrial" encompasses all private forestry operations.

to this area because, to the authors' knowledge, this is the first time that private (small commercial and industrial land owners) forestry pesticide data became part of the public record. Under Oregon's regulations, pesticide spray records are privately kept by the applicator and are not available to researchers or the public.

The purpose of this report is to provide both visual and quantitative information regarding the use of herbicides within the study area surrounding Triangle Lake, Oregon. This study area is a small, but representative portion of Oregon's industrial forestlands that are managed by spraying chemicals following clearcut logging. Similar forestry management occurs in private forested regions throughout western Oregon.

Beyond Toxics[3], an Oregon non-profit organization dedicated to protecting environment health, undertook this project for the following reasons:

- Access to three years of herbicide spray records presented the first ever opportunity to gather information about pesticide type, amount, frequency, acreage, location of application, proximity to streams, and proximity to residential areas.
- The state or federal agencies involved in the exposure investigation had no plan to analyze the pesticide records to learn about the impacts of pesticide applications in a watershed.

This analysis helps to answer the following questions and attempts to build a knowledge base about industrial forestry pesticide use:

- What can be learned about the use of pesticides in industrial forestry in Oregon?
- What insights can the data provide regarding impacts to human health from forestry pesticide spray as currently regulated under the Oregon Forest Practices Act?
- What information can the data provide regarding impacts to designated salmon habitat streams and the future survival of protected fish species under the Oregon Forest Practices Act?
- How does the Oregon Forest Practices Act compare to forest practices in neighboring states with similar forest ecosystems?
- How can this data inform Oregon forestry policy decisions?

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[3] Beyond Toxics is tax exempt under the Internal Revenue Code Section 501(c)(3).

Brief History of the Investigation

Forty-five complaints were made to the Oregon Department of Agriculture regarding the use of forestry herbicides from people in the Triangle Lake area between November, 2002, and September, 2011 (Oregon Department of Agriculture, 2011).

In January, 2010, members of the group Pitchfork Rebellion (an advocacy group formed by rural Triangle Lake residents) filed a petition with the U.S. Environmental Protection Agency asking for three things:

1. an unbiased study of the aerial application of herbicides and their impact based on actual conditions in the local area
2. a one-mile buffer around homes and schools until the study was complete
3. an investigation into the significance of the influence of big business on the EPA

The EPA published the petition in the Federal Register on April 28, 2010 (Vol. 75, Number 81, pp. 22401 - 22402), and requested public comments. The EPA accepted public comment on the petition, but has never responded to the petition itself. The EPA has taken no further action on the petition, but has indicated in public meetings that it is considering the petition as part of a comprehensive review of aerial pesticide applications and resulting problems from pesticide drift.

Members of the Oregon Board of Forestry, together with employees of the Oregon Department of Agriculture, representatives of Oregon's Pesticide Analytical and Response Center (PARC), the U.S. EPA as well as the Agency for Toxic Substances and Disease Registry (a component of the Centers for Disease Control and Prevention) toured the area in 2010 and heard residents' concerns. Beyond Toxics' Executive Director attended this and other forestland tours, met with U.S. EPA representatives, and introduced them to other rural residents who had similar complaints about forestry pesticide use but lived outside of the Triangle Lake area.

The Oregon Board of Forestry responded by working with Beyond Toxics and residents of the Triangle Lake area to schedule a two-part hearing regarding the use of herbicides on forestland in early 2011. During the first session, March 10, 2011, various state and federal agencies explained their roles in regulating pesticide use and application on private forestlands.

During the April, 2011 hearing, the Oregon Board of Forestry received testimony from Dana Boyd Barr, Ph.D., Research Professor, Environmental Health, Rollins

School of Public Health, Emory University, about urine testing she conducted on individuals living in the Triangle Lake, Oregon, area. Dr. Barr[4], former director of the Pesticide Exposure Assessment lab at the U.S. Centers for Disease Control and Prevention and a national authority on human exposure to pesticides, lent her equipment and skill to analyze urine samples collected from 43 people living near forest land in the Triangle Lake area of Western Lane County. Dr. Barr told the Board of Forestry that her testing showed all test subjects had been exposed to two herbicides[5], atrazine and 2,4-D, commonly used in industrial forestry.

Dr. Barr reported that she had found residue from 2,4-D and atrazine in 100% of test subjects' urine, even in baseline samples submitted before individuals knew of any exposure to herbicide sprays. Dr. Barr illustrated her results in Figure 1, which is a slide from her presentation (Barr, 2011).

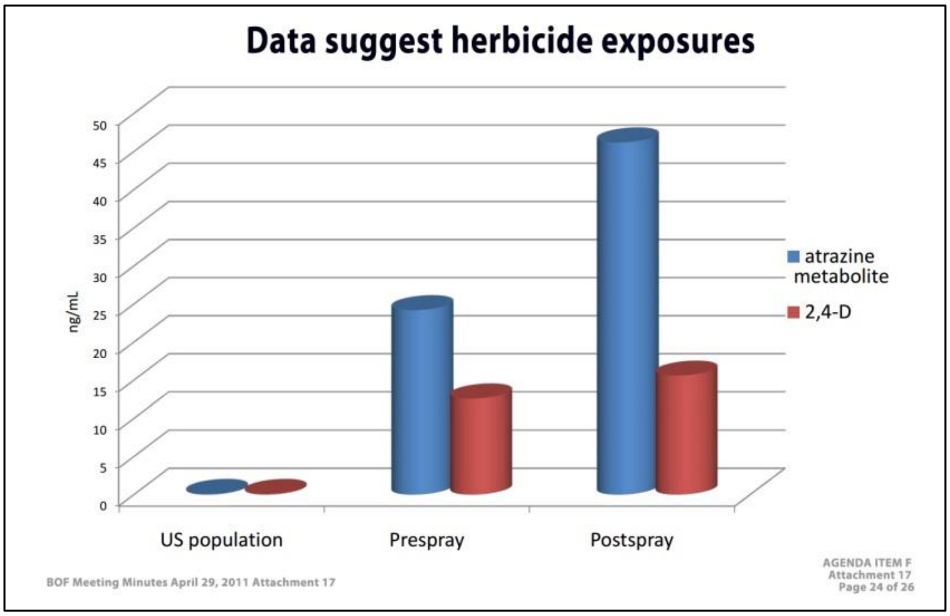

Figure 1. Dr. Barr's Results

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[4] Barr is a past president of the International Society of Exposure Science, and she finished a five-year term as Editor-in-Chief of the Journal of Exposure Science and Environmental Epidemiology in 2012.

[5] Atrazine and 2,4-D are the only herbicides sprayed in the study area that the CDC has developed a urine analysis test.

All of the urine samples contained 2,4-D and metabolites of atrazine, indicating exposure to these pesticide products. About a third of the original participants submitted a second urine sample after forestry aerial sprays in the Triangle Lake area. The second samples contained concentrations generally higher than pre-spray samples.

All samples had levels of 2,4-D statistically higher than the general US population.

It is more difficult to assess the safety level of atrazine metabolites in urine. The Centers for Disease Control and Prevention (CDC) does not have human health reference levels for atrazine metabolites. Consequently, it is not possible to determine how levels of atrazine in the urine samples for Triangle Lake residents compare to the general U.S. population.

Dr. Barr's testimony about the urine analysis results was the catalyst for an official health investigation into residents' exposure to forestry herbicides by the Oregon Health Authority (OHA), the U.S. Environmental Protection Agency, and the federal Agency for Toxic Substances and Disease Registry (within the Centers for Disease Control and Prevention). The investigation is titled *Public Health Assessment Highway 36 Corridor Exposure Investigation* (Oregon Health Authority, 2013). The Oregon Health Authority is the lead state agency.

In their draft report, OHA concluded that residents were exposed to herbicides in spring and fall 2011 (Oregon Health Authority, 2013, p. 3). Urinary biomarkers for atrazine and 2,4-D in people are verifiable indicators that residents were exposed to these two herbicides. It is concerning that residents of all ages (children to seniors) had atrazine and 2,4-D in their urine, and especially troubling these chemicals were found in the urine of children younger than age twelve. Neither health professionals nor the parents of these children have the necessary health data to understand this risk[6].

Access to Herbicide Spray Records

The Oregon Forest Practices Act, administered by the Department of Forestry, governs pesticide applications on forestland. The section of the Act addressing chemical use is Oregon Administrative Rules 629-620 (Chemical and other Petroleum Product Rules). The OHA asked the Oregon Department of Forestry to exercise their regulatory authority to request records of pesticide applications

[6] The Health Information Protection Act (HIPA) is designed to protect the privacy of medical records and serves to exempt study participants from disclosing the results of their urine samples as part of the public record. Beyond Toxics does not have access to the individual urine test results.

within an area surrounding Triangle Lake. Rules of the Department of Forestry (OAR 629-620-0600[4]) require timber operators to maintain records of pesticide applications on forest land for three years; records older than three years to the day may be destroyed by the pesticide applicator. Records within the three-year window are privately retained by the pesticide operator and made available only upon request by the State Forester, head of the Oregon Department of Forestry. The OHA requested the original records from the Oregon Department of Forestry in October, 2011. However, the records were not provided to the OHA until June, 2012.

Under the Oregon Forest Practices Act (FPA) the spray application records are not available to the public. The law specifies that only the State Forester may request the actual spray application records. Oregon Forest Practices Act requires that a Timber Operations Notification of intended logging operation, including logging and pesticide spray, be filed with the Oregon Department of Forestry. The public may pay to receive this Notification document. The Notification is informational only. It is not an application for a permit nor does it require agency review. These notifications list a variety of pesticides that may, or may not be sprayed anytime within the next twelve months. The public does not know when the sprays will occur or which pesticides will be sprayed in the field.

Interested residents in the Triangle Lake investigation study area submitted a public records request to the State of Oregon for the spray records, and then made those records available to Beyond Toxics.

The Triangle Lake residents who provided the forestry spray records are members of Beyond Toxics. Additional records were provided by the Department of Forestry in February, 2013, following inquiries from Beyond Toxics into pesticide spraying on state-owned forest land.

Methods and data sources used to analyze herbicide spray records are discussed in Appendix A.

Description of the Study Area

The study area consists of a total of eight Township/Range combinations, each consisting of 36 sections, with each of those sections consisting of 640 acres, or a total of 184,320 acres.

Triangle Lake, Oregon, is the name of both a 293-acre lake and an unincorporated community located to the west and slightly north of the Eugene-Springfield metropolitan area in western Oregon. Most of the area is located in the Siuslaw Basin, which means it drains to the Siuslaw River and then to the Pacific Ocean. Triangle Lake is within the Lake Creek watershed. Lake Creek flows into Triangle

Lake from the north, and flows out of Triangle Lake to the south. Just below the Lake Creek outflow is a natural rockslide. In 1989 the Bureau of Land Management (BLM) constructed a fish ladder allowing anadromous salmonid fish access to more than 110 miles of fish habitat in Triangle Lake and the upper part of the watershed. Before the construction of the fish ladder, anadromous salmonids were restricted to the watershed below Triangle Lake, although resident salmonid species, including cutthroat trout, have long been present above the Lake.

Downstream, Lake Creek joins the Siuslaw River near the community of Deadwood. The OHA Triangle Lake Investigation study area also includes portions of two other sub-basins: the Alsea to the north and the Upper Willamette to the east.

According to a real estate website (City-Data.com, 2013), there are approximately 5,010 people living in the area designated as Middle Siuslaw-Triangle Lake, Oregon, with an estimated median household income of $31,002 in 2009 compared to a statewide household income estimate of $48,457. According to interviews with residents, many of these families have lived on their property for multiple generations. Some are descendants of original settlers who chose to homestead in the area.

The study area is on the eastern side of the Coast Range Mountains, and the terrain is often steep, with many streams cutting through to carry the high levels of precipitation that fall on the area. The average annual precipitation for Blachly, Oregon, is 78.49 inches (Blachly is within the investigation study area). Forest lands are located in the higher elevations of the area. Most residents live in the valleys, many clustered near State Highway 36, which loosely follows the path of Lake Creek. Many residents live downwind and downstream of private industrial timberland where herbicide spraying is conducted (Figure 2). The area is served by Triangle Lake Charter School, which is located just off Highway 36 a few miles north of Triangle Lake. The school serves children in kindergarten through 12th grade.

The study area is characterized by a dense network of streams and rivers. Lake Creek and its tributaries flow through the study area and provide important salmon and steelhead habitat. The Oregon Department of Fish and Wildlife has identified over 170 miles of waterways for Coho salmon, a salmon species on the federal endangered species list. Fish Creek, a sub-watershed within the Lake Creek watershed, has been designated a Core Cold Water Salmon Habitat Stream by the Oregon Department of Fish and Wildlife (Oregon DEQ, 2003a); attributes of a Core Cold Water habitat include ample gravel for spawning free of fine sediments, cold, clean, and well-oxygenated water.

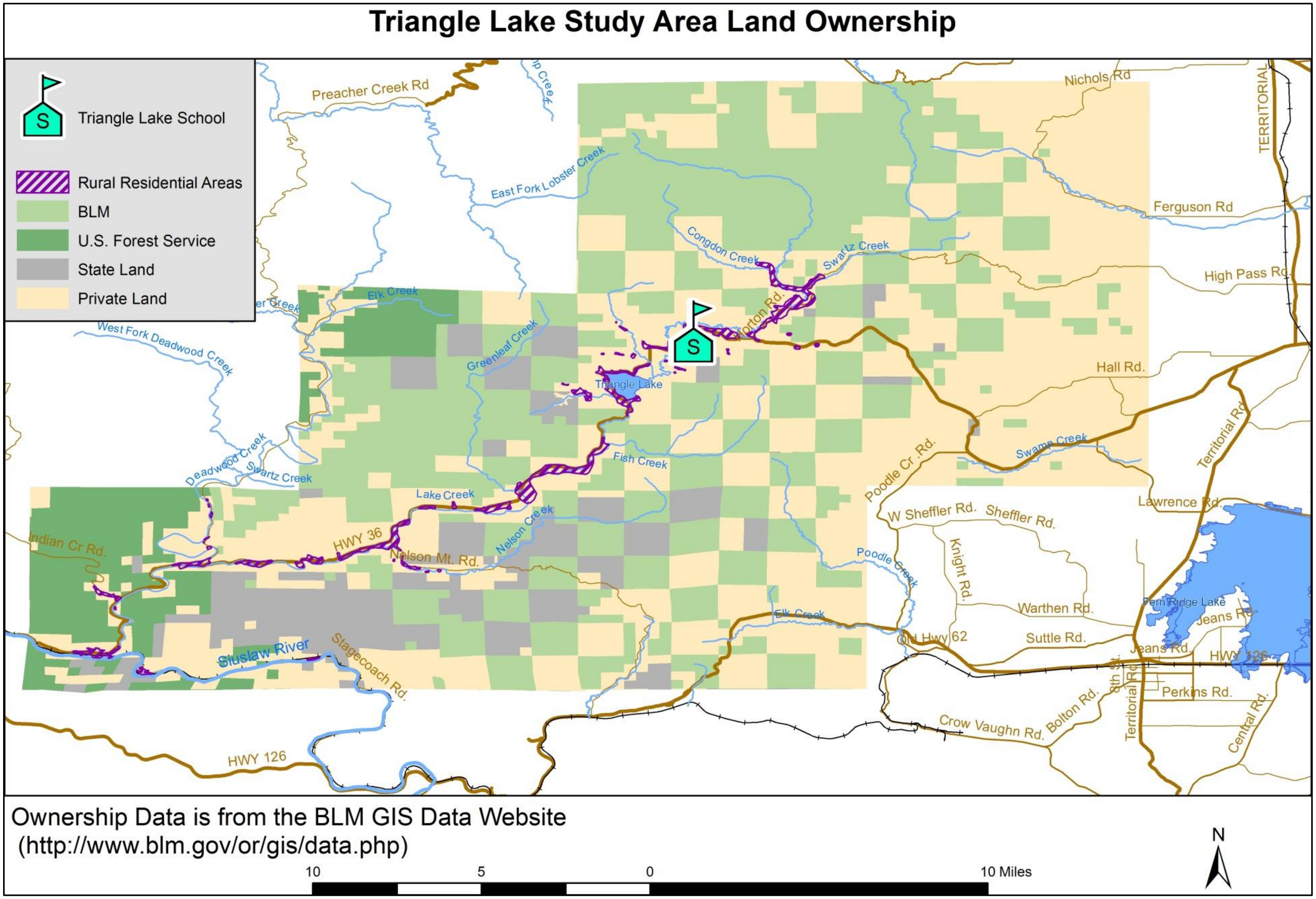

Figure 2. Land ownership within the Triangle Lake Study Area

Land Ownership Patterns

In the Triangle Lake area, forest lands are owned privately or are managed by the state or federal government. State-owned forest land is in multiple parcels, much of it clustered around Nelson Creek. Federally owned forest land is primarily managed by the BLM and was formerly part of land owned by the Oregon and California Railroad. In 1916 these forest lands reverted to federal ownership and are part of what are frequently referred to as the "O&C Lands" managed by the BLM. The Siuslaw National Forest, managed by the U.S. Forest Service, occupies land in the southeastern portion of the study area. Much of the BLM land is in a "checkerboard" land ownership pattern, with alternating sections of private and public ownership. Figure 2 shows the private, state, and federally owned forest land and the checkerboard ownership pattern.

Figure 3 shows the percentage of private, state and federally managed land in the study area, together with the zoning of privately owned land (State of Oregon, 2011).

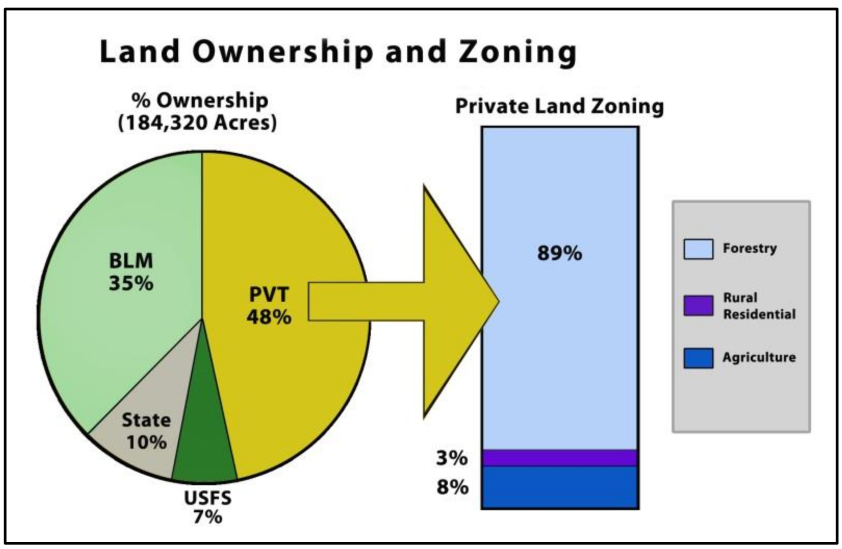

Figure 3. Percent Land Ownership in the Triangle Lake Study Area

The Siuslaw Basin historically supported high levels of salmon, and was one of the most productive Oregon coastal Coho salmon watersheds. However, Coho salmon are currently listed as threatened under the U.S. Endangered Species Act. Coho, steelhead and Chinook salmon spawn and rear in the waters of the Triangle Lake area, as well as seagoing and resident cutthroat trout, rainbow trout, and other resident fish species. Other natural resources in the area include the threatened Northern spotted owl and Marbled Murrelet, many natural wetlands, and rare plants. The area is also home to many Native American cultural sites.

Pesticide Application Spray Records Data Analysis

Methods Used to Analyze Quantity of Pesticides

Herbicide products come in a variety of formulations, including liquids, concentrated liquids, dispersible granules, and dry flowable powders. Some of these products are sold using liquid measures (gallons, quarts, fluid ounces); others are sold using weight (pounds, ounces). It should be noted that these figures are for pesticide products purchased commercially, and include so-called "inert" ingredients. Federal law does not require manufacturers to identify these "inerts." Inert ingredients are also known to have toxic properties.

For the purpose of comparison in this report, quantities of liquid chemicals were initially converted to gallons, and then mathematically converted to pounds so that the amount of all pesticide products could be conveyed in a single measure. To do so, the product labels and MSDSs (Material Safety Data Sheets) were downloaded from various sites on the Internet. In some cases, the number of pounds per gallon of pesticide product was stated on the label or MSDS; in most cases, pounds per gallon were not stated directly. A figure was given for either density or specific gravity. This was used to calculate a ratio of the weight of a gallon of pesticide product to the weight of a gallon of water (8.3454 pounds was used), and that ratio was used to determine the number of pounds per gallon of the pesticide product.[7]

The majority of land is sprayed by helicopter. Pesticide tanks are attached under the rotating blades and the chemical is released from a boom.

Various ground-based systems were used, including pressurized ground sprays from vehicles, and hand-application methods including backpack sprays, spot sprays, hack and squirt (the stem of vegetation is cut and pesticides are injected using a squirt bottle) and other methods.

Aerial application records generally provided all information required by the Oregon Administrative Rule 629-620-0600, however, many records of ground-based applications lacked one or more items of information required. When it was possible to locate the notification of a pesticide application[8] in the Oregon

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7 Only one pesticide product (Milestone VM-Plus) lacked any figures for pounds per gallon, density or specific gravity. In that one case, pounds per gallon was estimated at 9.51, which is the same as pounds per gallon of Milestone and Milestone VM. Since only 6 gallons of Milestone VM-Plus were used in the Study Area over the three-year period, it was felt that any error introduced by the use of this estimate was less than 10 pounds and therefore insignificant.

8 Oregon Forest Practices Act requires that a Notification of intended logging operation, including logging and pesticide spray, be filed with the Oregon Department of Forestry. The Notification is informational only. It is

Department of Forestry's database FACTS (Oregon Department of Forestry, FACTS website), additional information, such as acres sprayed, was added if it was missing from the application record. However, a group of records, in particular those from 2010 with the suffix "-RRC," could not be located in FACTS. In some records the amount or type of pesticide used could not be determined. Therefore, both acres sprayed and amounts of pesticide products applied by ground spray should be considered low estimates.

Location of Aerial and Ground Sprays

Large tracts of Oregon's private forest land are clearcut and sprayed annually. Figure 4, Figure 5 and Figure 6 display the locations of aerial and ground sprays for all three years of data released by the Oregon Department of Forestry, 2009-2011. Some ground sprays occurred on state forestry land. Several ground sprays are missing from these maps since acreage and location were sometimes omitted from application records. Roadside sprays on private logging roads are also not included on the map.

Each map contains a list of herbicides and adjuvants in the top left corner, with corresponding abbreviations. Spray units are labeled with these abbreviations to indicate which chemicals were sprayed. Various pesticide products are often mixed together in a tank and applied to the land.

not a permit or an application nor does it require agency review. Residents may receive copies of Notifications by registering to receive Notifications with ODF and by paying a fee for each notification requested.

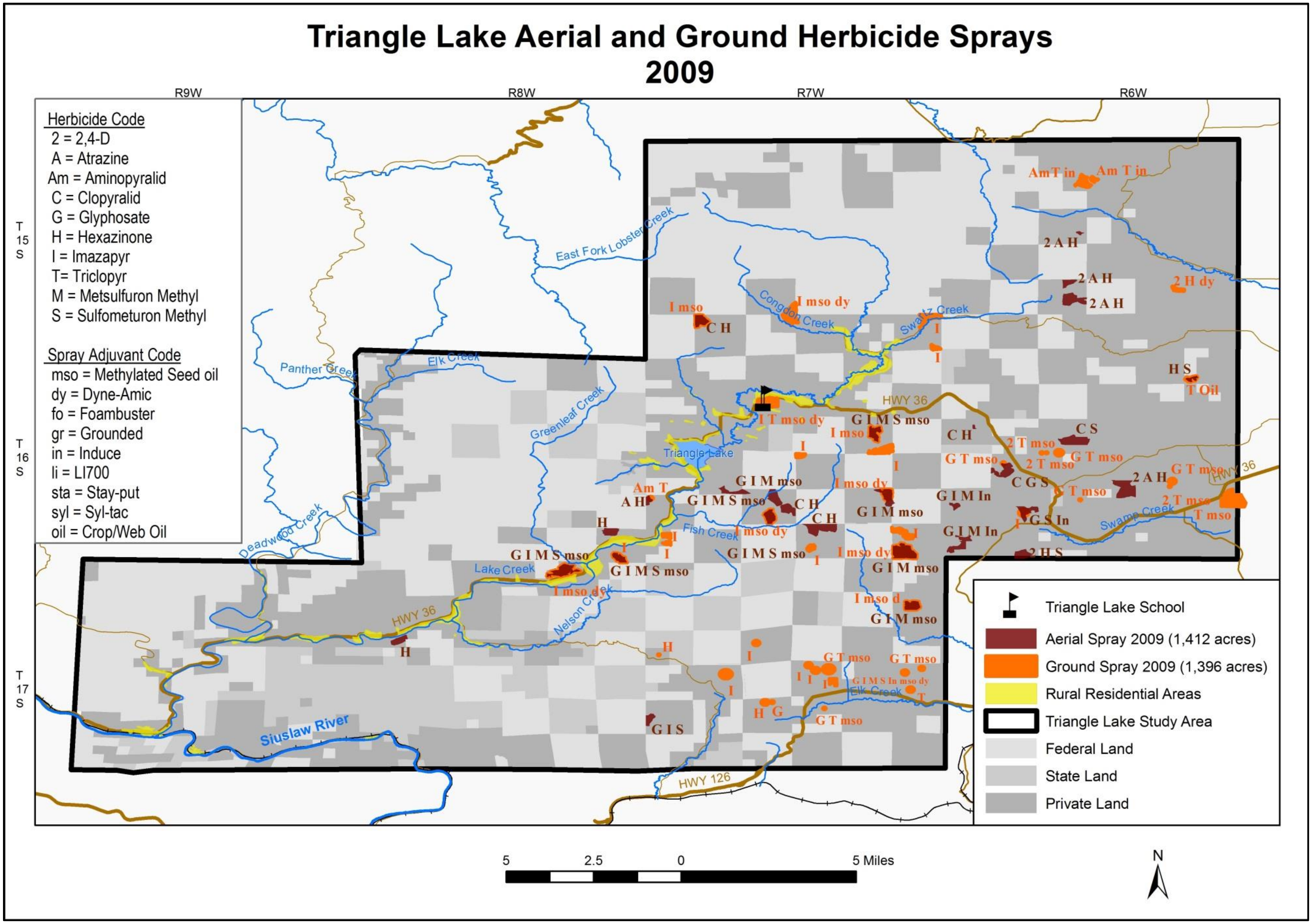

Figure 4. Aerial and ground pesticide sprays in 2009.

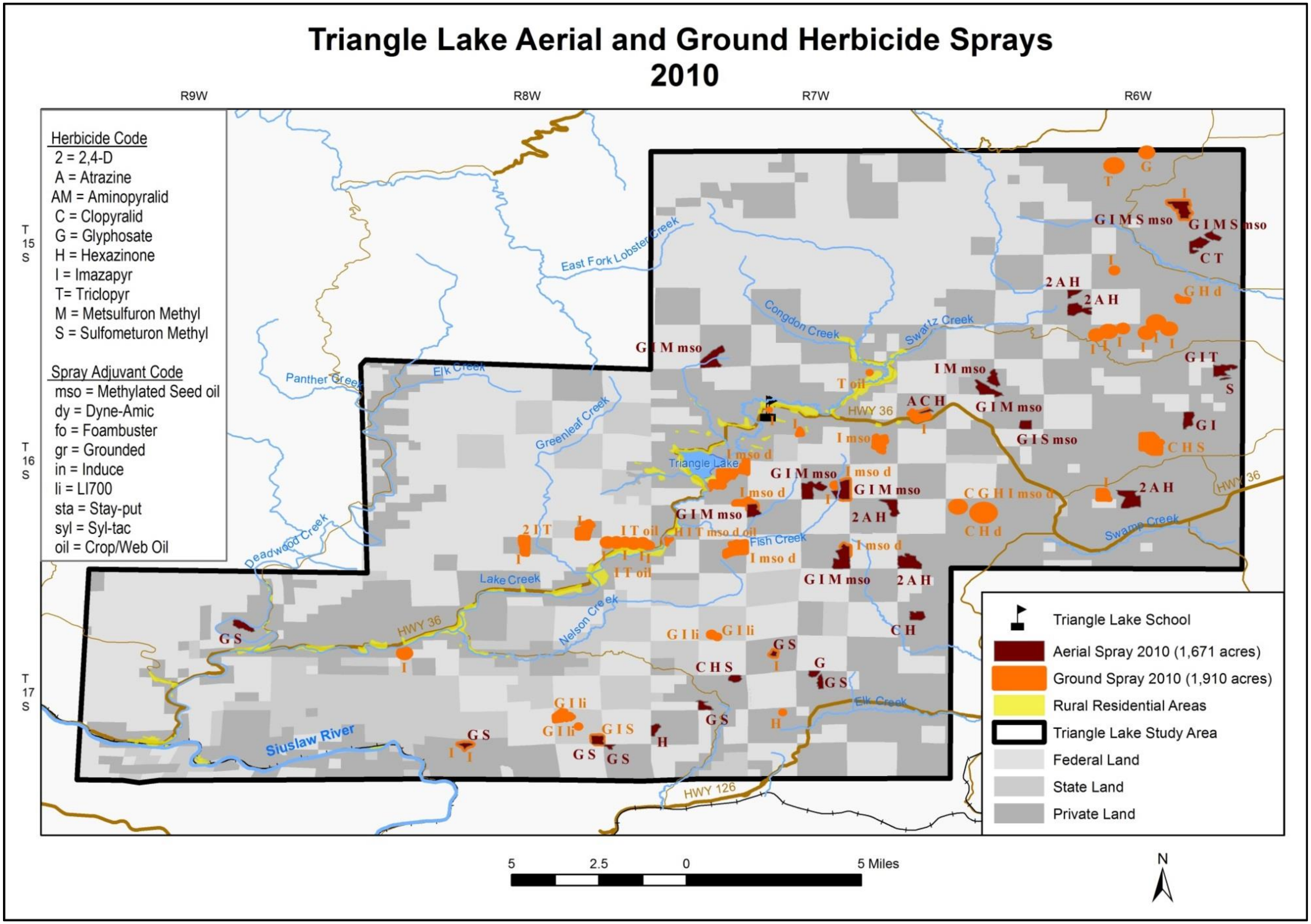

Figure 5. Aerial and ground pesticide sprays in 2010.

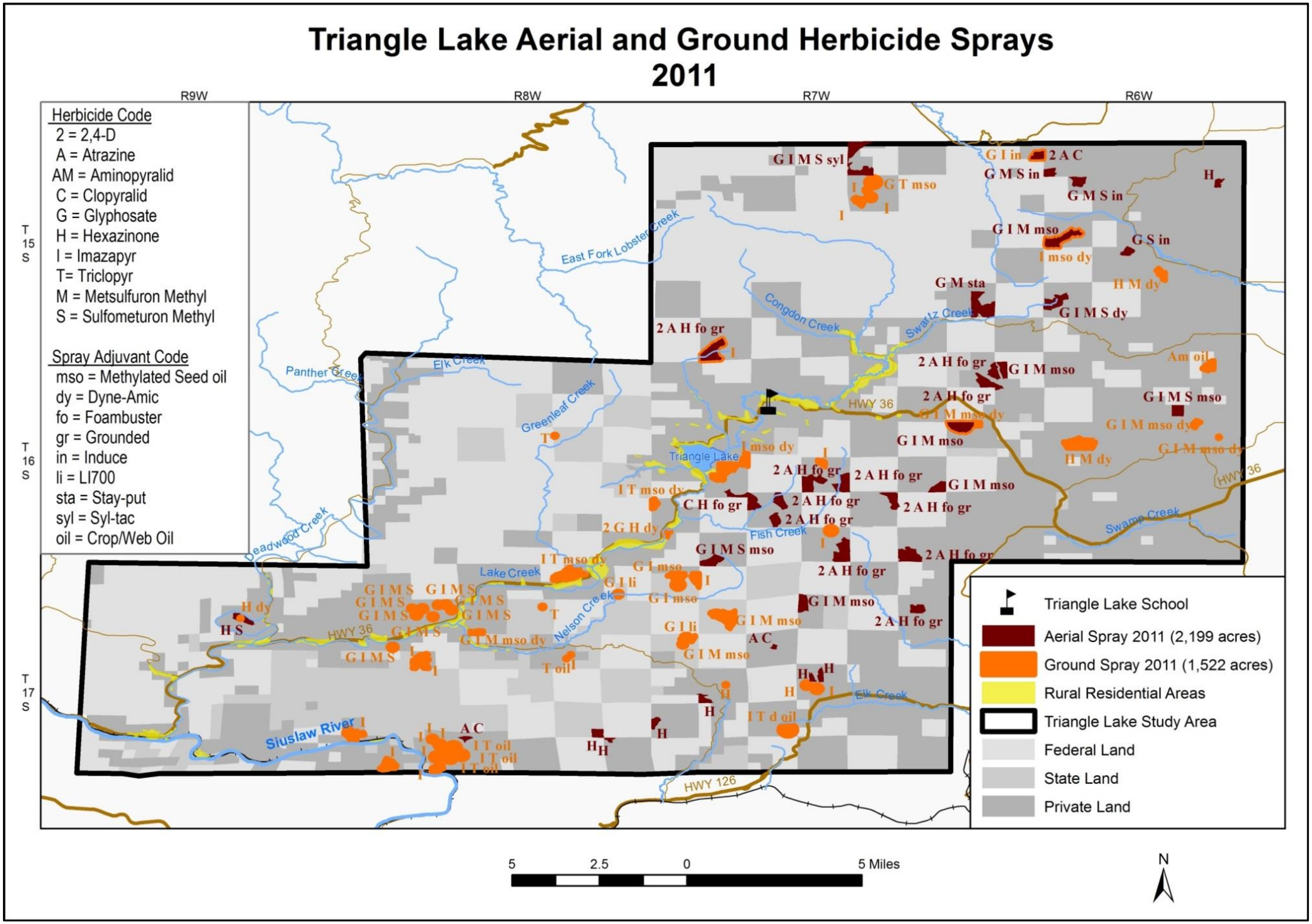

Figure 6. Aerial and ground pesticide sprays in 2011.

Pesticide Tank Mixes

Spray records reveal that forestry spray operators combine various active ingredients and adjuvants into tank mixtures, or, as they are referred to by foresters, "chemical soups." Regulations do not cover the practice of mixing active ingredient and adjuvants. Choices of tank mixes are made independently by the pesticide applicator. Examples of tank mixtures listed in the spray records are:

- GIM mso: Glyphosate-Imazapyr-Metsulfuron Methyl-Methylated Seed Oil
- 2AH fo gr: 2,4-D- Atrazine-Hexazinone-Foambuster-Grounded
- CH fo gr: Clopyralid- Hexazinone-Foambuster-Grounded

Note that some tank mixes contain both 2,4-D and atrazine, the two chemicals that were tested for and detected in the urine samples taken by Dr. Barr.

Under the current Oregon Forest Practices Act, the public can access notifications of pending sprays but cannot access spray records. The notification lists a wide variety of pesticides that may, or may not, be sprayed, and omits any reference to mixing chemicals. Appendix B is an example of a Weyerhaeuser spray notification for a unit in Lane County. At least twenty-two pesticide products and nine adjuvants are listed for one unit to be aerially sprayed. Before application spray records were available through the OHA Exposure Investigation, the standard practice of mixing chemicals was not public knowledge.

Regulatory agencies and policy makers have not addressed the question of how combining active ingredients may affect drift, re-volatilization, chemical interactions or persistence in the environment. There is little to no environmental testing of synergistic effects on living organisms from chemical tank mixes used in the Triangle Lake Study Area and elsewhere in Oregon.

Table 1 lists all chemicals and adjuvants used:

Table 1. Chemicals and adjuvants sprayed on industrial and state forestry land.

Chemical Herbicide	Spray Adjuvants
2,4-D	Methylated Seed Oil
Atrazine	Dyne-Amic
Aminopyralid	Foambuster
Clopyralid	Grounded
Glyphosate	Induce
Hexazinone	LI700
Imazapyr	Stayput
Triclopyr	Syltac
Metsulfuron Methyl	Crop/Web Oil
Sulfometuron Methyl	

Research suggests that mixing chemicals can lead to synergistic effects. Chemicals applied in a mix can interact with each other, which may result in more harmful environmental effects than when applied individually (Laetz, 2009) (Hayes, 2006). In other words, the effects of synergistic doses cannot be predicted by the effects observed at single doses. Consequently, the impacts to people, fish and other organisms from these tank mixes are not clearly understood and they cannot be considered scientifically sound practices. In a literature review published by the U.S. National Center for Biotechnology Information (Silins & Högberg, 2011), researchers suggest that chemicals that act as endocrine disrupters and carcinogens have long-term impacts via epigenetic mechanisms. The authors concluded, "solid evidence shows that these groups of chemicals can interact and even produce synergistic effects." Even lesser amounts of herbicides within a chemical mix may produce toxic impacts during sensitive windows of vulnerability, such as fetal development and early childhood. Refer to Appendix C for a further literature review on synergistic and low dose effects.

The OHA Exposure Investigation (Oregon Health Authority, 2013) did not discuss effects from synergistic effects of chemical tank mixes. Chemical interactions should not be overlooked in exposure investigations. In the least, OHA should consider identifying synergistic effects as an area for future inquiry.

Adjuvants

Adjuvants are separate products that are added to pesticides to increase its effectiveness. Some adjuvants cause the product to adhere to or penetrate the leaf surface; reduce drift; or reduce foaming when pesticide products are diluted. Adjuvants identified in spray records include the following[9]:

- Methylated seed oil – *enhances the consistency or performance of certain postemergence herbicides …. improves leaf coverage and absorption*
- Foambuster – a *silicone defoamer for use in aqueous solutions*
- Dyne-Amic – a *proprietary blend of highly effective nonionic surfactants and a refined and modified spray oil*
- Grounded – a *specialized blend of surfactants and aliphatic hydrocarbons designed to enhance the deposition and absorption of both ground and aerial spray applications*
- Sta-put – a *deposition aid" that can improve deposition in the target swath and can retard, but not totally prevent drift*

[9] The descriptive phrases are quoted from the product label.

- Syl-Tac – *a blend of modified seed oil concentrate and a silicone surfactant*

Much like synergistic effects from chemical tank mixes, the effects of individual adjuvants and adjuvants mixed with active ingredients are unknown. Cox and Surgan (2006) summarize potential environmental health concerns:

> *Inert ingredients can increase the ability of pesticide formulations to affect significant toxicologic end points, including developmental neurotoxicity, genotoxicity, and disruption of hormone function. They can also increase exposure by increasing dermal absorption, decreasing the efficacy of protective clothing, and increasing environmental mobility and persistence. Inert ingredients can increase the phytotoxicity of pesticide formulations as well as the toxicity to fish, amphibians, and microorganisms.*

The OHA Exposure Investigation (Oregon Health Authority, 2013) did not discuss effects from adjuvants.

For spray records reporting using adjuvants, methylated seed oil was most frequently used. It accounted for eighty-eight percent of all adjuvants. Table 2 shows quantities of adjuvants that were disclosed on pesticide application records.

Table 2. Pounds of Adjuvants Reported 2009 through 2011

Adjuvant Product	Aerial (lbs)	Ground (lbs)	Total (lbs)
Methylated Seed Oil	2,899	2,093	**4,992**
Dynamic	17	0	**17**
Foambuster	6	0	**6**
Grounded	218	0	**218**
Induce	163	13	**176**
Staput	64	0	**64**
LI700	0	73	**73**
Herbimax	0	138	**138**
Totals	**3,367**	**2,317**	**5,694**

Repeated Application

In accordance with Oregon administrative rules, spray records are only kept for three years. As a result, 2009 records were the oldest available to investigators. Figure 7 displays units that were aerially sprayed once, twice or three times within the three year period. The assessment of spray records, made possible by the OHA Exposure Investigation, revealed that the same clearcut units are sprayed multiple years and multiple seasons. This forestry practice could not be confirmed until spray records were studied. The data confirm that it is common practice for units to be sprayed several years in a row.

Figure 7 illustrates the ownership patterns of federal, state and private lands. In Figure 7, the federal lands are light gray and the state lands are dark gray. Privately owned land is depicted by an underlying aerial photo. The aerial photo helps us understand the extent of logging on private lands. The three years of data reveal a trend of units being sprayed multiple years. Although the data is unavailable, there is a high likelihood that older clearcuts were sprayed prior to 2009. A three year window of data limits our understanding of the temporal and spatial extent of spraying.

In addition, Figure 4, Figure 5 and Figure 6 reveal that same units aerialyl sprayed were commonly ground sprayed in the same year. The combination of aerial and ground spray is repeated for multiple years in a row.

Cumulative effects of repeated sprays are not fully understood. Pesticide products may resist degradation in the environment. Environmental persistence is determined by a number of factors. Research from USGS (1998) found that atrazine persists substantially longer in ground water or subsoils than in top soils. Atrazine was found to be persistent in soil generally ranging from 14-109 days; in some soils it can persist to at least four years (U.S. EPA, 2007). Residues of 2,4-D can enter streams by inflow or runoff of herbicide previously deposited in soils or by leaching through the soil column (U.S. EPA, 2007). In water, 2,4-D will biodegrade at a rate dependent upon the level of nutrients present, temperature, availability of oxygen and whether or not the water has been previously contaminated with 2,4-D or other phenoxyacetic acids (Halter, 1980).

To the authors' knowledge, no study has been conducted to determine the persistence of forestry herbicides in soils and surface and ground water from applications repeated on a seasonal and annual basis. Repeated sprays of atrazine, 2,4D and other herbicides at the same location may have a cumulative effect, especially for organisms within the soil and aquatic organisms necessary for fish survival.

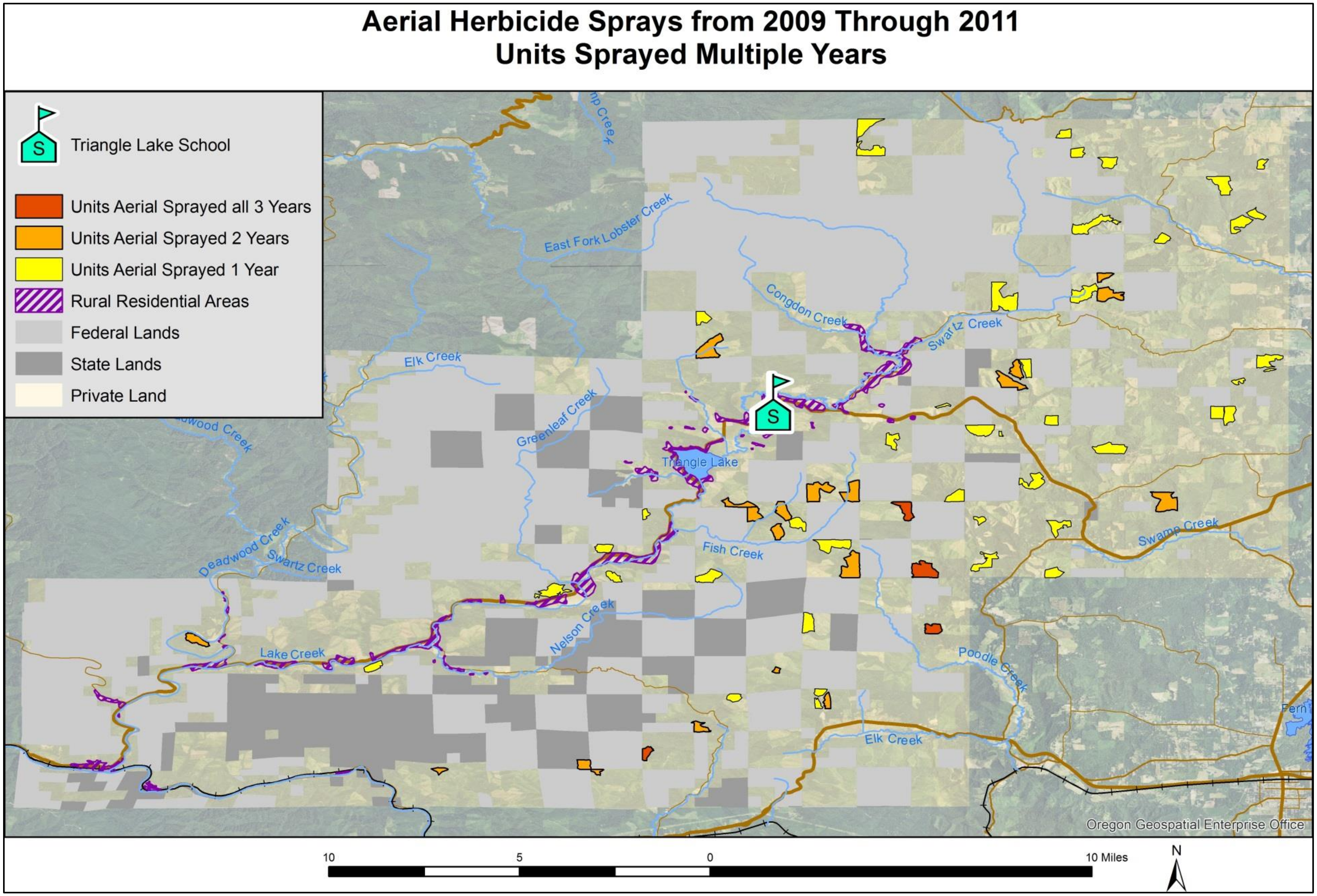

Figure 7. Units aerially sprayed multiple years.

Percentage of Land Receiving Aerial Spray

The number of acres of zoned private forestland in the study area (76,917 acres) was calculated using GIS ownership data from the Oregon Spatial Data Library (State of Oregon, 2011).

- In 2009, 1,412 acres were aerially sprayed amounting to 1.8% of the total private land zoned for industrial forestry;
- In 2010, 1,617 acres were aerially sprayed amounting to 2.2% of the total private land zoned for industrial forestry;
- In 2011, 2,199 acres were aerially sprayed amounting to 2.9% of the total private land zoned for industrial forestry.

The calculations above do not include ground sprays or roadside sprays on logging roads.

Looking at the trend of increasing number of acres sprayed does not tell the entire story. The incremental difference between 1.8 and 2.9 may not appear to be a significant difference. However, as displayed in Table 3, there is a much higher increase in acres exposed to aerial pesticide spray when comparing the difference from one year to the next. From 2009 to 2011 there was a 56% increase of aerially sprayed acres.

Table 3. Increase in aerially sprayed acres on private forestlands.

Years	% Increase of Aerially Sprayed Acres
2008 to 2009	unknown
2009 to 2010	15%
2010 to 2011	36%
2009 to 2011	**56%**

Because it is difficult to predict trends with only three years of data, does this pattern indicate an increase of acres aerial sprayed and an increasing use of pesticides in the study area? At a larger scale analysis, the question arises: is there an increase in aerial applications and pesticide use throughout all industrial forestry operations in Western Oregon?

Table 4 provides an in-depth calculation of the number of acres sprayed with an individual pesticide product per year. The table does not include ground sprays because of poor recordkeeping (some records lacked numbers of acres sprayed).

Tank mixes can result in two or three pesticide products sprayed over the same unit. When this occurs the acres are counted individually for each pesticide product. For example, if a hundred acres were sprayed with a tank mix of 2,4-D and atrazine, those hundred acres would be listed under both chemicals.

Table 4. Acres aerially sprayed per pesticide product

Pesticide Product	2009 (acres)	2010 (acres)	2011 (acres)
2,4-D	278	401	886
Atrazine	245	401	915
Clopyralid	359	151	159
Glyphosate	746	1,041	960
Hexazinone	571	540	118
Imazapyr	619	881	679
Metsulfuron Methyl	335	604	493
Sulfometuron Methyl	314	263	82
Triclopyr	0	135	0

Calculating the number of acres sprayed per chemical demonstrates significant increases in acres sprayed with 2,4-D, atrazine and glyphosate. The number of acres sprayed with 2,4-D and atrazine more than doubled for each successive year in this brief period. Increased logging may be the reason. The data may also indicate a shift to using some chemicals more than others. Both conditions may be relevant: Weyerhaeuser increased their number of timber operations they carried out during this brief time frame and was the only company to rely extensively on tank mixes of 2,4-D and atrazine. Furthermore, it is not possible to determine if timber companies re-sprayed acreage as a result of targeted plants developing an increased resistance to herbicides.

Quantity of Pesticide Product Applied by Aerial and Ground Practices

The majority of application records were for private industrial forestlands. In the study area the Oregon Department of Forestry manages 10% of the land. From that data supplied by the Oregon Department of Forestry, the following information was determined:

- State forests in the study area were managed using ground sprays; it appears that the state did not use aerial sprays.
- Records received were for the years 2010 (59 acres) and 2011 (234 acres), for a total of 293 acres of state forest land ground sprayed.
- The majority of sprays occurred in the fall months using glyphosate, imazapyr, and metsulfuron methyl.
- A few records were filed for logging road sprays in June and July; in this case Triclopyr BEE was used.

Table 5 lists the amount of individual pesticide products[10] for aerial sprays on private industrial lands and ground sprays on private and state lands.

Figure 8 displays the total pounds of pesticide products aerially and ground sprayed per year. Each consecutive year shows an increase in pounds sprayed. Figure 9 looks at the individual chemicals sprayed. Atrazine, 2,4-D, glyphosate, hexazinone and imazapyr are the most common pesticide products aerially sprayed. Glyphosate, hexazinone, imazapyr and triclopyr are typically used for ground sprays.

[10] Pesticide Product is the active and inactive (inert) ingredients as listed on the product label, but does not include the carrier (such as water).

Table 5. Pounds of Pesticide Products Applied to Triangle Lake Study Area, 2009–2011

	2009		2010		2011		Total		
Pesticide Product	**Aerial**	**Ground**	**Aerial**	**Ground**	**Aerial**	**Ground**	**Aerial**	**Ground**	**Total (% of Total)**
2,4-D	625	25	921	21	3,166	32	**4,711**	**78**	**4,789 (12%)**
Atrazine	1,718	0	2,761	0	6,449	0	**10,928**	**0**	**10,928 (26%)**
Aminopyralid	0	27	0	0	0	48	**0**	**74**	**74 (<1%)**
Clopyralid	241	0	102	109	96	0	**439**	**109**	**548 (1%)**
Glyphosate	3,613	368	5,145	341	3,773	1,280	**12,531**	**1,990**	**14,521 (35%)**
Hexazinone	716	62	433	942	1,154	87	**2,303**	**1,111**	**3,414 (8%)**
Imazapyr	913	329	1,236	781	1,049	864	**3,198**	**1,956**	**5,154 (12%)**
Metsulfuron Methyl	44	0	70	1	52	17	**135**	**18**	**153 (<1%)**
Sulfometuron Methyl	104	1	70	9	104	29	**278**	**39**	**317 (1%)**
Triclopyr	0	387	255	229	0	561	**255**	**1,177**	**1,432 (3%)**
Total Pounds	**7,973**	**1,198**	**10,961**	**2,435**	**15,844**	**2,918**	**34,778**	**6,551**	**41,329**

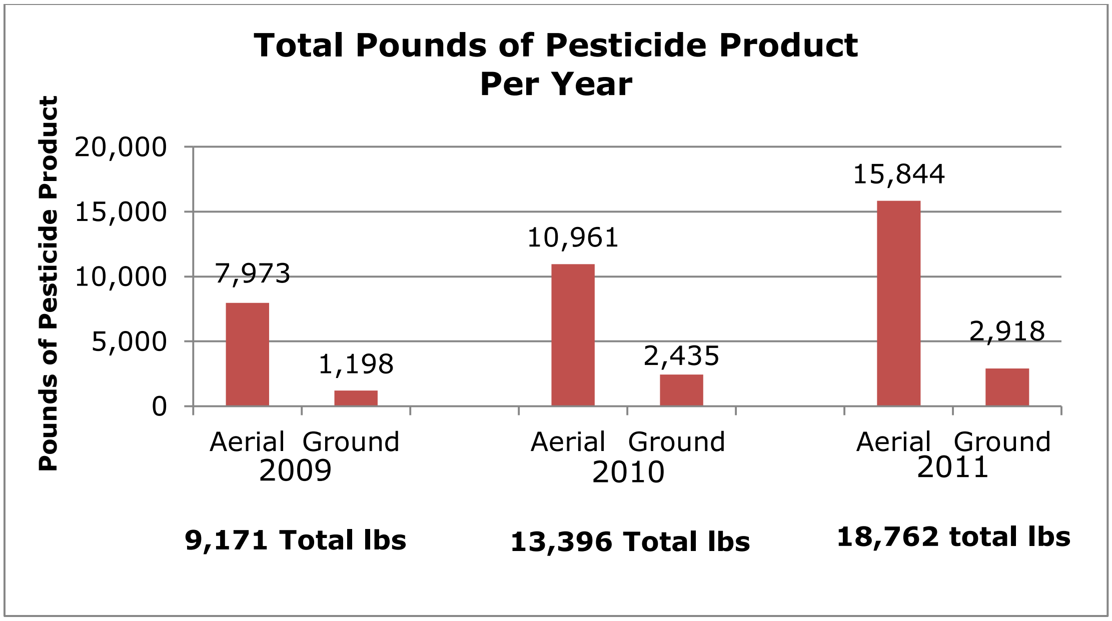

Figure 8. Pounds of pesticide product aerially and ground sprayed each year

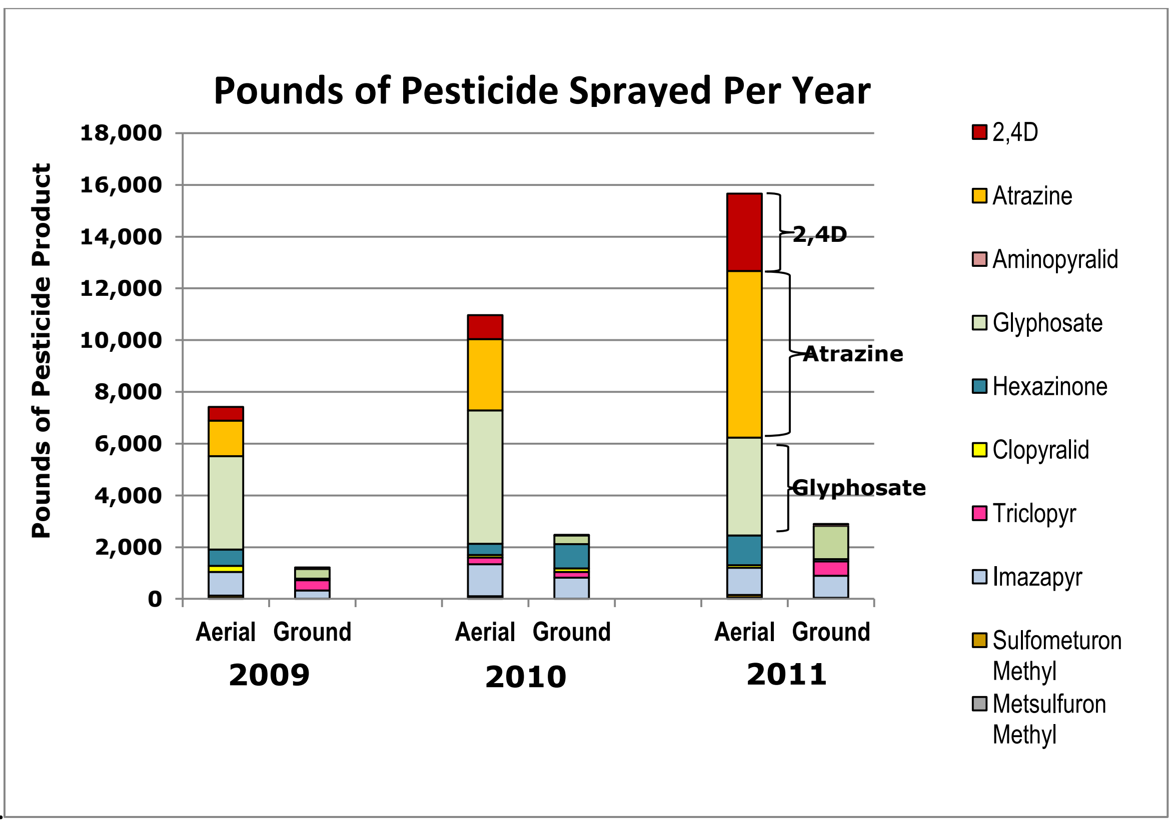

Figure 9. Individual chemicals aerially and ground sprayed by year

Table 6 shows the percent increase in the pounds of pesticide product most commonly sprayed.

Table 6. Percent increase of pounds of pesticide product most often sprayed from 2009 to 2011

Pesticide Product	Aerial Sprays	Ground Sprays
2,4-D	80%	22%
Atrazine	73%	N/A*
Glyphosate	4%	71%
Hexazinone	38%	29%
Imazapyr	13%	62%
Triclopyr	Increase cannot be calculated, sprayed in 2010 only	31%

* Atrazine is used exclusively in aerial spray operations.

Pounds of Pesticide Product per Acre

The data show an increasing trend in the amount of pesticide product applied by helicopter (Table 7). This trajectory warrants further analysis, particularly since it is difficult to establish a trend with only three years of data.

The pounds per acre of aerial spray increased despite the fact that some pesticide products, such as sulfometuron methyl and metsulfuron methyl, are highly toxic in very small amounts. Chemicals with the highest toxicity ratings usually require fewer pounds per acre. Nonetheless, their environmental impact may be greater than other pesticides applied in larger quantities. In other words, because a more potent chemical may require less spray, comparing pounds of pesticide product does not provide a complete picture of increasing toxicity in the environment. Even so, pounds of pesticide product increased from 5.6 to 7.2 pounds per acre (Table 7). This is a 29% increase in pounds per acres aerially sprayed from 2009 to 2011.

By federal law, an applicator must apply the pesticide product in accordance with the product label. The rate of application is determined by pounds per acres. Data supplied by pesticide applicators on the spray records consistently report spray rates at or below the rate permitted on the product label. The increased rate of spray seen over three years indicates a greater concentration of chemicals released into the environment. It is complicated to understand the reasons for increased pounds of herbicide per acre. This may be a result of choice of chemical, an increased rate of pesticide applied per acre, or the additive effect of multiple chemicals in a tank mix that are simultaneously applied to land.

Table 7. Pounds of pesticide product per acre by year

Year	Pounds/Acre Aerial Sprayed
2009	5.6
2010	6.6
2011	7.2

Seasonal Trends

Aerial Sprays: Figure 10 shows which chemicals were aerial sprayed during the spring and late summer/fall seasons. Spring aerial sprays occurred between March and May. The late summer/fall season sprays were from August through the beginning of October. Atrazine, 2,4-D and hexazinone were the most common chemicals aerially sprayed during spring months, while glyphosate and imazapyr were more common in the late summer/fall months.

Increased aerial spray activity in 2011 was especially evident in the spring months (Figure 10), with a 226% increase in pounds of pesticide product applied by aerial spray from Spring 2009 to Spring 2011. Spring 2011 is when all of the forty-three residents who provided urine samples tested positive for 2,4-D and atrazine. Atrazine, used exclusively in spring aerial spray operations, increased by 73% (Table 6). The chemical 2,4-D is primarily applied by aerial spray in the spring, and increased 80% from 2009 to 2011.

Ground Sprays: Figure 11 displays seasonal data for ground sprays. Ground spray occurred during most of the year. Spring sprays occurred between March 21 and June 20, summer sprays were from June 21 through September 20 and fall sprays occurred from September 21 through December 20. The chemicals in ground spray operations tended to be triclopyr, imazapyr, hexazinone and glyphosate. With the exception of hexazinone being sprayed only in spring months, there is no clear trend for chemicals sprayed by season. Glyphosate was sprayed year round and there was an increase in spraying during summer months.

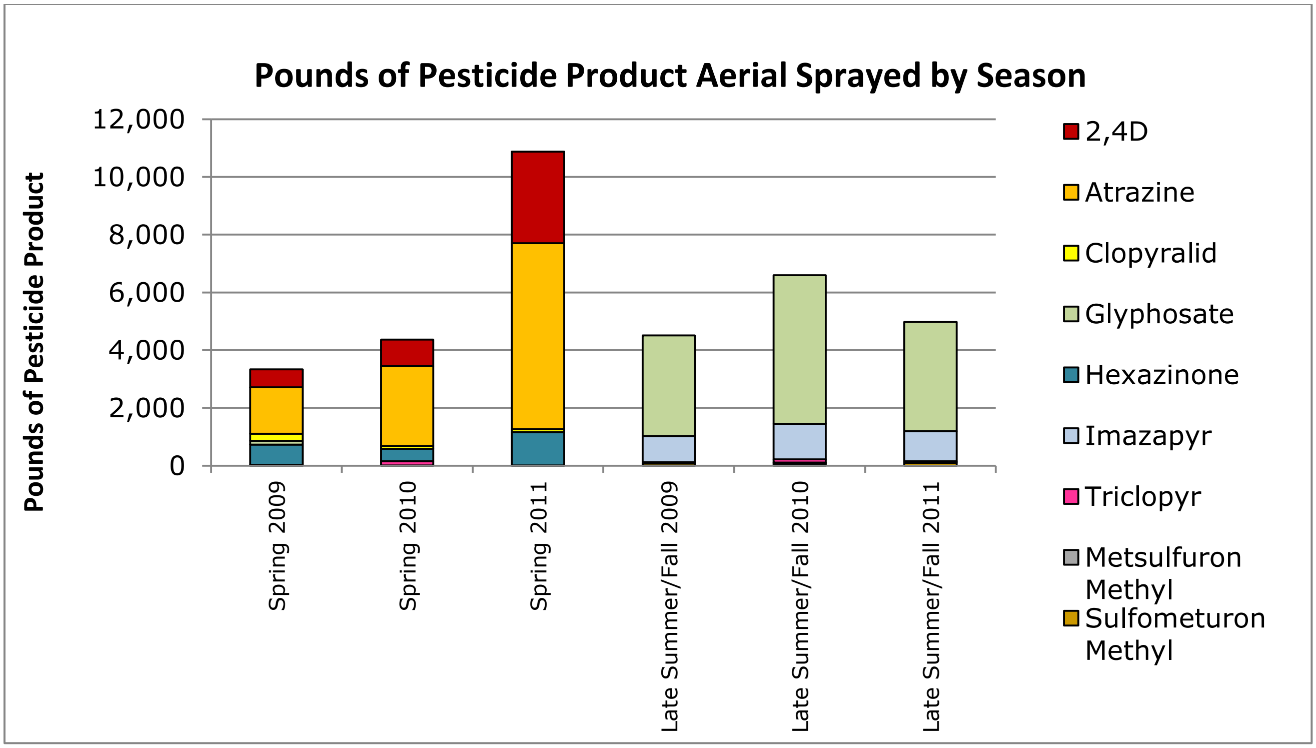

Figure 10. Chemicals used and seasonal trends for aerial sprays

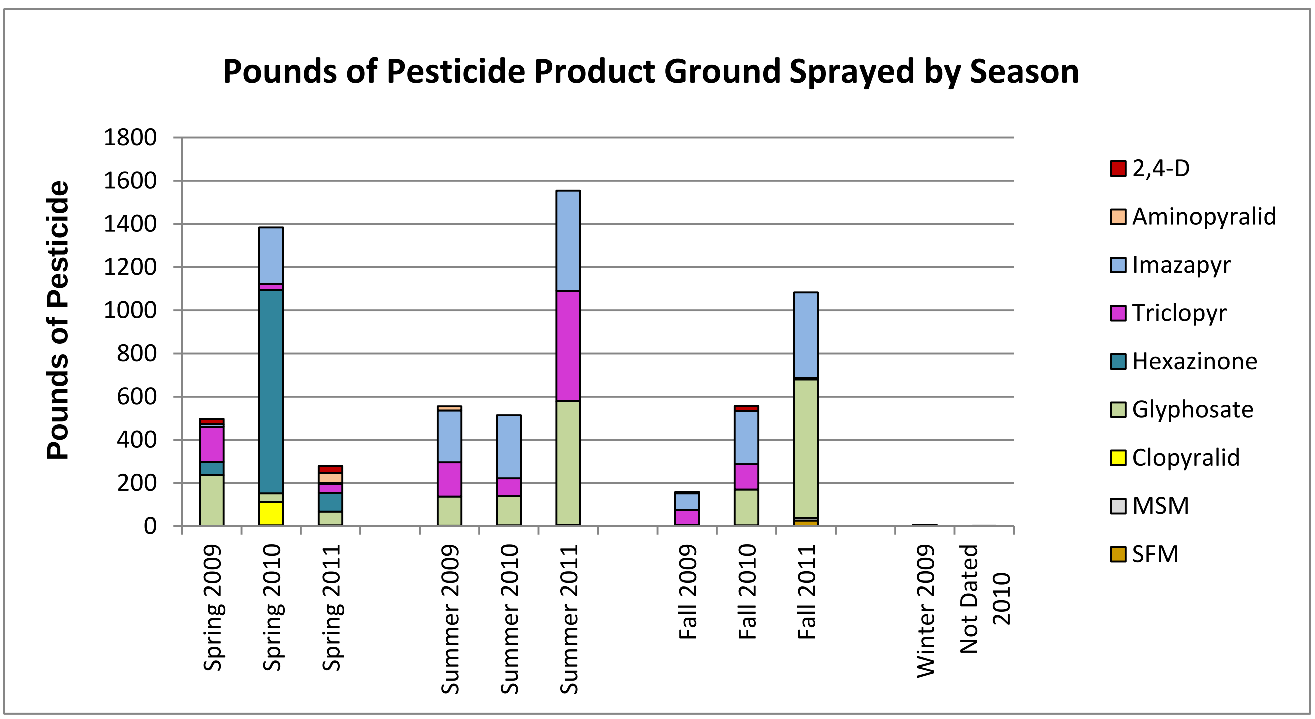

Figure 11. Chemicals used and seasonal data for ground spray

EIQ Analysis

The Environmental Impact Quotient (EIQ) is a methodology pioneered by Joseph Kovach, Ph.D., and colleagues (1992) at Cornell University to establish a standardized way to determine the relative dangers to humans and the environment from a pesticide's active ingredient. The EIQ rating is a number that estimates environmental impact by taking into account toxicity to wildlife and humans, degree of exposure and aquatic and terrestrial effects as well as soil chemistry. The quotient of the environmental impact assessment is derived from thirteen variables:

- Dermal Toxicity
- Chronic Toxicity
- Reproductive Toxicity
- Teratogenic Toxicity
- Mutagenic Toxicity
- Oncogenic Toxicity
- Fish Toxicity
- Bird Toxicity
- Bee Toxicity
- Beneficial Arthropods
- Soil Persistence
- Runoff Potential
- Leaching Potential

The EIQ rating system compares individual herbicide applications by the rate of application and the chemical choice. This provides a relative value that summarizes the potential risk a herbicide application poses to both the environment and human health. The higher the number, the greater the negative environmental impact for that particular choice of chemical(s).

Figure 12, Figure 13 and Figure 14 provide a relative rating for each aerial spray operation in 2009, 2010 and 2011, respectively. These charts help us understand that a timber operator's choice of 2,4-D, atrazine and hexazinone (all chemicals sprayed in the spring) have the highest environmental impacts relative to other pesticide products sprayed. This rating system can help us determine which companies have a higher environmental and public health impact. Kovach (personal communication) suggested that a rating larger than 10 is a toxicity concern.

Regulatory agencies administering the Oregon Forest Practices Act have not used an environmental impact assessment tool that could provide comparative information about the level of environmental harm associated with common industrial practices.[11]

[11] Oregon State University is currently involved with creating an updated and improved method similar to this rating system that will be more applicable to this study (PRIME, 2013).

Figure 12, Figure 13 and Figure 14 display an EIQ rating for individual aerial sprays. The landowner, date of application and acres sprayed are listed on the X-axis. The relative EIQ rating is on the Y-axis. Each column represents one unit that was sprayed. If more than one herbicide is listed, it indicates a tank mix was sprayed on that unit. The height of the column is the cumulative value of the EIQ rating for that spray application.

The EIQ rating provides an understanding that some chemicals are more toxic in the environment. Notably 2,4-D, atrazine and hexazinone, all sprayed in the spring, contribute to the highest EIQ ratings.

The EIQ was developed more than 20 years ago and may not reflect recent discoveries of environmental and health effects from pesticides. Impacts from these pesticides could be more toxic than what is displayed in the graphs below. Kovach (personal communication) also confirmed that synergistic effects from tank mixes are not considered for the EIQ rating. However, Kovach did approve adding individual active ingredients for each tank mix for this analysis.

Forestry management practices used by Weyerhaeuser (WEYCO), the largest landowner in the study area, has the highest environmental impact quotient. This is not a result of number of acres sprayed, but using tank mixes that include 2,4-D, atrazine and hexazinone.

In 2011 (Figure 14) there was a dramatic increase in number of acres sprayed with high EIQ ratings, particularly in the spring. These EIQ ratings correspond to when Triangle Lake area residents complained to the Oregon Pesticide Analytic Response Board (PARC) about their illnesses. Spring 2011 was also when residents' urine samples tested positive for 2,4-D and atrazine. The Oregon Health Authority concluded on pages 2 and 31 of their Draft Report (2013) that 2,4-D in the urine samples collected in spring and fall 2011 were "higher than those found in the general population;" spring samples were "significantly higher." The report goes on to state that levels of atrazine metabolites in urine samples were statistically higher immediately following a known application of atrazine (page 31). There are no human health reference values for atrazine available for the general population. Consistent with spray records, atrazine was detected in spring and not fall urine samples.

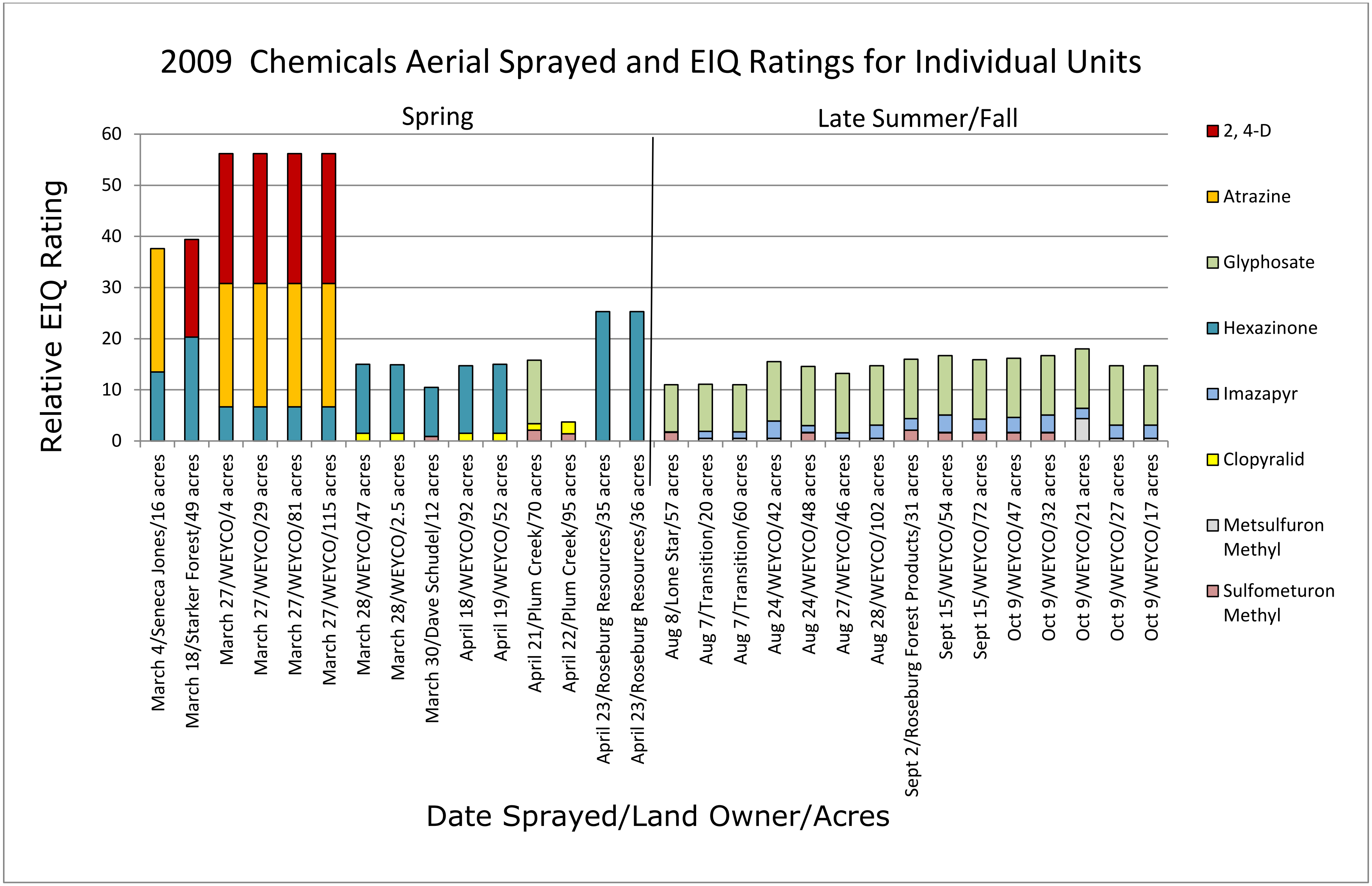

Figure 12. Chemicals aerially sprayed in 2009 and cumulative EIQ Ratings

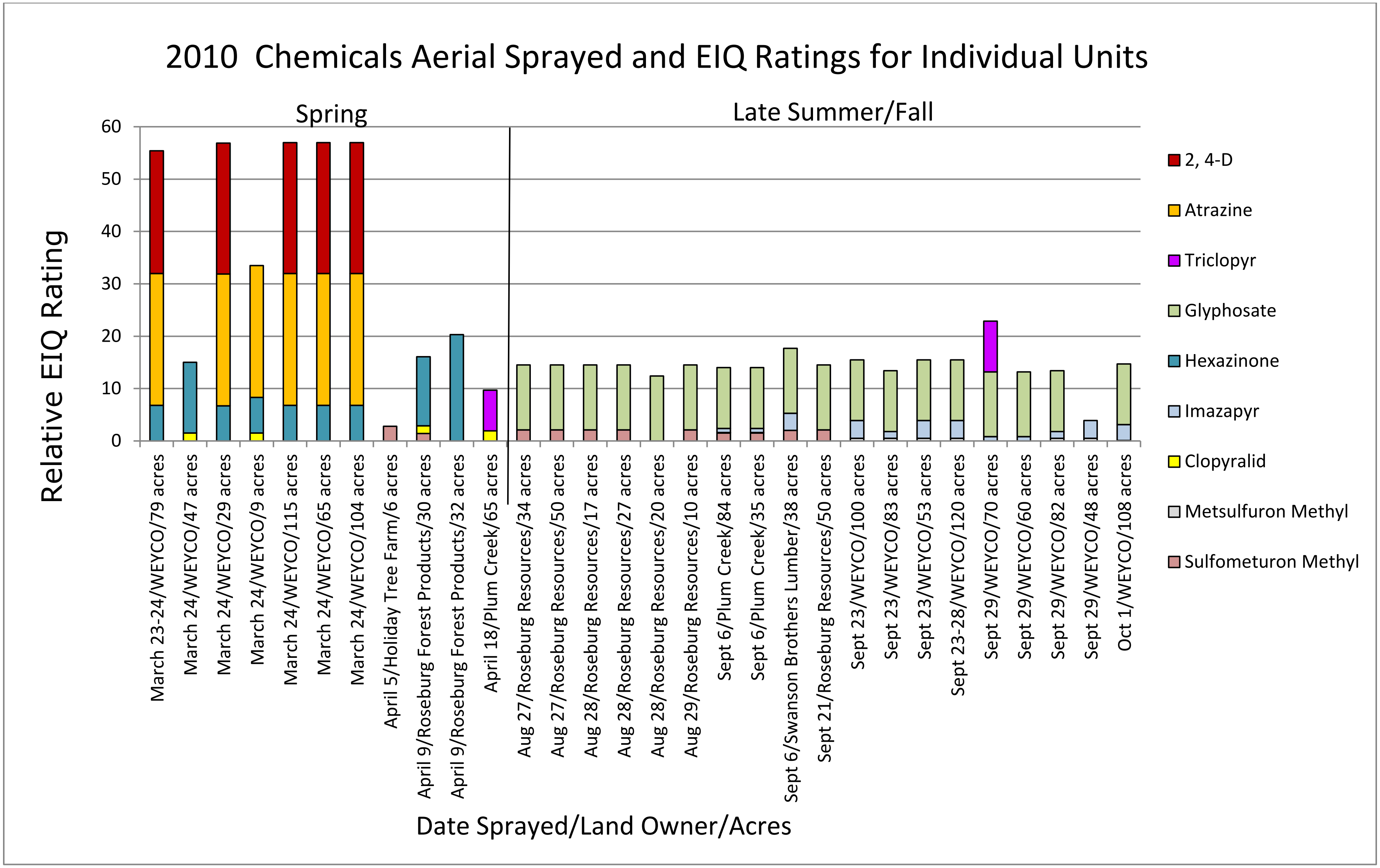

Figure 13. Chemicals aerially sprayed in 2010 and cumulative EIQ Ratings

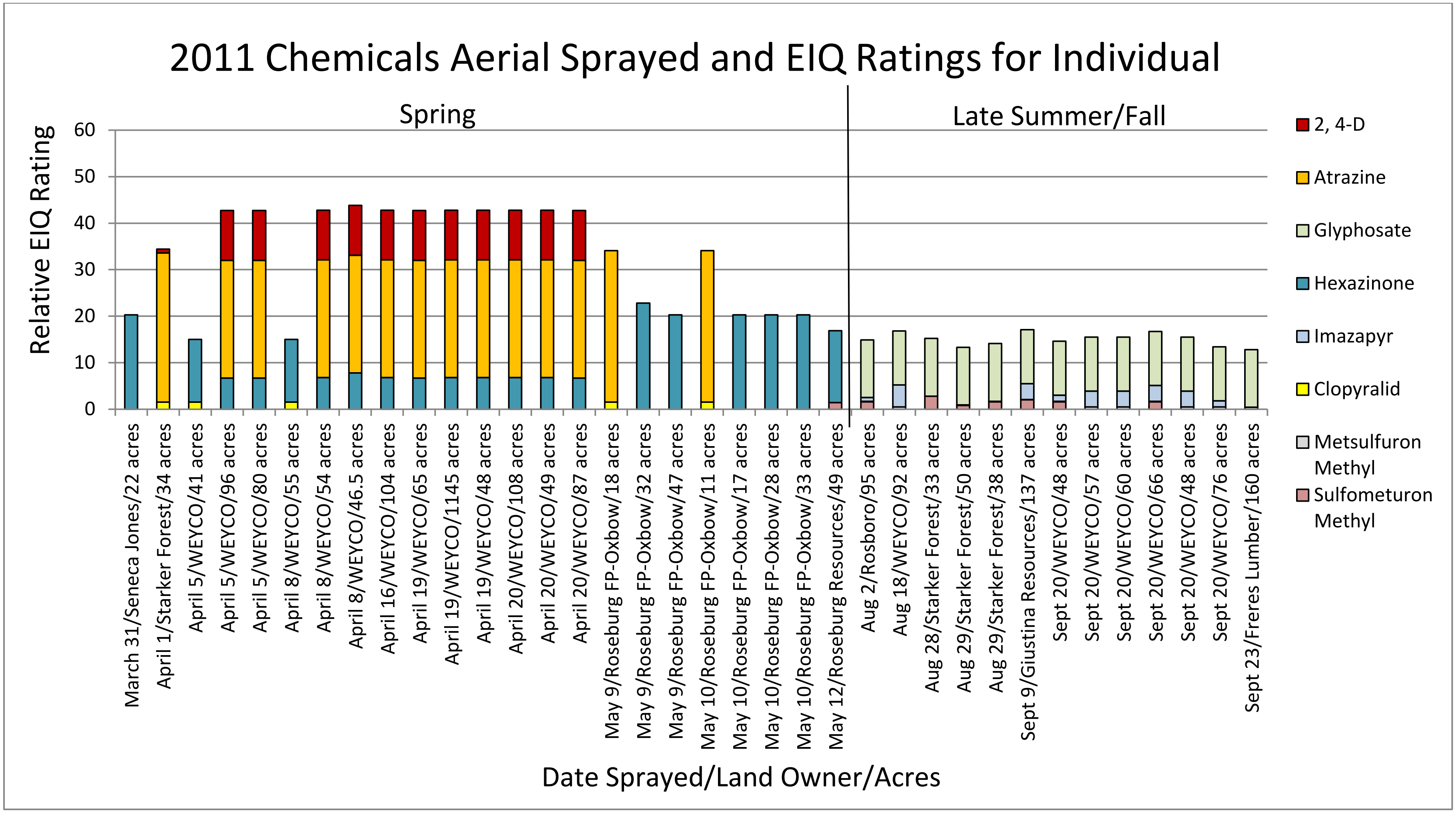

Figure 14. Chemicals aerially sprayed in 2011 and cumulative EIQ Ratings

Summary of Pesticide Spray Record Data Analysis

Tank Mixes: The majority of aerial spray applications are tank mixes. Applicators apply a mix of pesticide products. The synergistic interactions of these chemicals are unknown.

Adjuvants: These additives can be toxic and their environmental impacts are not well known. The use of these products and their synergistic and cumulative effects are overlooked in research, practice and policy.

Repeated Applications: Although limited to three years of data, it is clear that chemical applications take place on the same sites on consecutive years. Sprays repeated on a seasonal and annual schedule may contribute to the persistence of toxic chemicals in soil and water. These repeated applications can increase the potential for chronic exposure to people and aquatic species

Percentage of Land Receiving Aerial Spray: The number of acres aerially sprayed on private forest lands increased 56% from 2009 to 2011. More data are needed to determine if this trend will continue and if a similar increase is occurring throughout Oregon.

Pesticide Products Most Often Used in Aerial and Ground Sprays: Atrazine, 2,4-D, glyphosate, hexazinone and imazapyr are the most common pesticide products aerially sprayed. Glyphosate, hexazinone, imazapyr and triclopyr are more often used for ground sprays.

State Forest Land Management: In the study area, state forests were managed using ground sprays only. Atrazine and 2,4-D were not sprayed on state land.

Quantity of Pesticide Product Aerially and Ground Sprayed: The practice of aerial pesticide sprays in industrial forestry is widespread. During the three years of analysis, aerial sprays comprised 84% (34,778 pounds) of all pesticide products applied and ground sprays made up 16% (6,532 pounds).

The number of pounds applied increased dramatically from 2009 to 2011. There was an increase in the quantity of every pesticide product released into the environment.

- The total pounds of pesticide product increased by 99%.
- There was a significant increase in the quantity of atrazine (73%) and 2,4-D (80%). Atrazine was applied solely by aerial spray.

Pounds of Pesticide Product per Acre: According to written spray records, the rate of pesticide spray was at or below the rate permitted on the product label; however the pounds of pesticides applied per acre increased from 5.6 to 7.2. This may be a result of the choice of chemical, an increase in the rate of pesticide applied per acre or the additive effect of multiple chemicals in a tank mix that are simultaneously applied to land.

Seasonal Trends for Aerial Spray: Atrazine, 2,4-D and hexazinone are sprayed in the spring, while glyphosate and imazapyr are sprayed in the late summer/fall months.

There was a 226% increase in pounds of pesticide product applied from Spring 2009 to Spring 2011. This significant increase in aerial sprays occurred when local residents complained of illness and when urine samples tested positive for 2,4-D and atrazine.

EIQ Analysis: Atrazine, 2,4-D and hexazinone, all sprayed in the spring, contribute to the highest EIQ ratings. These EIQ ratings also correspond to complaints of illness from Triangle Lake area residents. The EIQ ratings verify that the most harmful practices occur during spring months when young salmon are emerging from gravels, birds are nesting, and most other plants and animals are reproducing.

Forestry management practices used by Weyerhaeuser, the largest landowner in the study area, has the highest environmental impact quotient. This is a result, not of number of acres sprayed, but using tank mixes that include 2,4-D, atrazine and hexazinone.

EIQ ratings can be used as a tool to help industrial timber land owners maximize their integrated pest management strategies and choose least toxic management practices.

Additional Factors that Increase Pesticide Exposure

Drift and Volatilization

The U.S. EPA reports there are various ways pesticides can move from sites where they are applied into the surrounding environment (U.S. EPA, 2009). The EPA considers all pathways of pesticide exposure including drift, volatilization and re-volatilization to be potentially harmful. Pesticide drift occurs when pesticides move off the application site into the air as particles or aerosols and when dust coated with pesticides travels away from the application area. Spray drift can result in pesticide exposures to nearby rural communities, tree planters, children playing outside, and wildlife and its habitat.

Volatilization occurs when pesticide surface residues change from a solid or liquid to a gas or vapor; re-volatilization occurs when the change to a gas or vapor occurs over days during diurnal cycles of heating and cooling of vegetation and soils. Airborne, volatile pesticides can move long distances off site. For example, in their Chemical Summary of Atrazine, the EPA found atrazine particulates and vapors could be transported up to 186 miles from the site of application (U.S. EPA, 2007). Re-volatilization is a different exposure pathway than drift since it can recur over a period of days.

Topography can influence the impacts of pesticide drift on water quality. Over 184,000 acres within the study area are characterized by steep slopes that create a "canyon-like" effect. Residents state that dense layers of coastal fog caused by humidity, temperature and wind currents travel up and down the valley. Air currents and fog may play an additional role in increasing the range of pesticide drift, deposition and re-volatilization.

Regarding chemical drift, the U.S. EPA bases their application requirements on studies conducted using fixed wing aircraft over flat agriculture fields. In the agriculture environment aircraft can fly in a horizontal flight path close to the fields. The label requirements for chemicals used in forestry applications are based on these studies. The following topographic factors in Western Oregon may increase the potential for pesticide drift and re-volatilization:

- Steep terrain with high ridges and deep valleys
- High stream density
- Extremely variable winds
- Frequent precipitation
- Fog inversions that hold moisture in the air

Drift, volatilization and re-volatilization are significant, but overlooked, exposure pathways. For reasons mentioned above, drift deserves special consideration in exposure investigations. The OHA Highway 36 Corridor Exposure Investigation (Oregon Health Authority, 2013) suggests aerially applied pesticides can drift at least two to four miles from an application site.

Other Sources of Pesticides

Regarding pesticides found in the drinking water, surface water and urine of Triangle Lake residents, there are other potential sources besides applications to private forestland. However, most of them are not present in significant amounts within the study area.

Both the U.S. Forest Service and the Bureau of Land Management have long-standing policies that have prevented the routine application of pesticides on public land in Oregon for many years. Also, aerial spraying of pesticides is not allowed on federally-managed land in western Oregon.

Agriculture is a potential source of pesticides in the study area. However, its role as an exposure pathway may be minimal because only 8% (Figure 3) of the land in the study area is zoned for agriculture. The OHA Exposure Investigation (Oregon Health Authority, 2013) indicated on page 61 that only 1.8% of the acres treated with herbicides occurred on agriculture lands in 2011. The main source of pesticide use in agriculture comes from Christmas tree farming. Christmas tree management uses both aerial and ground pesticide sprays. There are several Christmas tree farms in the study area, and more to the east and north of the study area. Christmas tree harvesting is regulated as a farming practice in Oregon, and is not subject to the Oregon Forest Practices Act. The OHA Exposure Investigation did not include the spray application records of Christmas tree operations; thus, it is not possible to include that data in this study.

Road sprays are another potential source of pesticides in the area. Lane County has a policy of not using herbicides in its vegetation management on county roads. However, herbicides are ground sprayed along Highway 36, which is managed by Oregon Department of Transportation (ODOT). Spray records provided by ODOT to Beyond Toxics show glyphosate, triclopyr and aminopyralid were the most common herbicides used along Highway 36. Atrazine and 2,4-D were not used.

An exception to ODOT's application of herbicides is a no-spray zone along Highway 36 in the immediate vicinity of Triangle Lake (mile post 24.03 to 32.12). The organization Beyond Toxics obtained a permit from ODOT to remove weeds manually along this 8.09 mile section of Highway 36 that runs through the middle of the study area. The purpose of the no-spray area is to reduce pathways of pesticide exposure to protect human health and water quality in Lake Creek.

The bulk of herbicides used for road maintenance are on forestland roads. Spray records included several applications on forest roads. However, all forest road applications are done from the ground, and none of the ground-based operations used atrazine in the study area during the 2009 to 2011 study period. In general, glyphosate and triclopyr were used for roadside sprays.

To summarize, roadside, farming or private pesticide uses were not likely pathways of exposure for urinary detection of 2,4-D and atrazine. Obtaining agricultural records would help verify if agricultural sprays, particularly on Christmas tree farms, were a pathway for human exposures.

Human Health and Chemical Forestry Practices

Urine Testing in the Triangle Lake Study Area

In the spring of 2011, residents in the Triangle Lake area filed complaints with the State of Oregon about health problems they believed were related to exposure to pesticide exposure. Following health complaints from residents, Dr. Dana Barr tested for and detected atrazine and 2,4-D in the urine of residents in the study area.[12] The test was limited to atrazine and 2,4-D because these two active ingredients are the only pesticides for which Dr. Barr's lab analysis protocols have been developed. Residents may or may not have other pesticides in their urine, but there was no test available to determine such exposures.

There was an exponential increase of aerial applications of quantities of atrazine (73%) and 2,4-D (80%) (Table 6). No other pesticide products sprayed aerially had an increase of this magnitude.

Spray records indicate that atrazine and 2,4-D were both sprayed multiple times by private timber companies. Atrazine was sprayed 14 times between April 1 and May 20, 2011 and 2,4-D was sprayed twelve times between April 1 and April 20, 2011. Post-spray urine samples were taken April 9, April 16, May 13, May 18 and June 1. Both chemicals were detected in all urine samples collected during the spring of 2011. The chemicals applied during April and May 2011 were, in order of quantity, atrazine, 2,4-D, hexazinone and a negligible amount of clopyralid (Figure 10).

Figure 14 lists pesticides, application dates and the land owner for each spray. Table 6 combined with Figure 14 provide an understanding of the correlation between increased frequency and quantity of atrazine and 2,4-D in spring 2011 aerial sprays and the post-spray urine analysis results. In hindsight, the aerial spray record data help confirm why there were increased health complaints during spring 2011 from rural residents in the study area.

Atrazine and 2,4-D were not aerial sprayed in the late summer or fall months. The OHA Exposure Investigation (Oregon Health Authority, 2013) found no atrazine metabolites in the fall urine samples. However, 92% of these participants had detectable levels of 2,4-D in their urine. Strikingly, 42% of participants had

[12] Urine sample data are considered medical records and were not available for this analysis due to regulations on rights of privacy.

detectable levels of 2,4-D above the 75th percentile of the 2003-2004 National Health and Nutrition Examination Survey, a study that helps determine the levels detectable in the general U.S. population. It is notable that levels of pesticide metabolites were found to be above the 75th percentile despite the fact that 2,4-D was last sprayed on April 20, six months prior to the fall urinalysis. Researchers should be asking about the persistence of these chemicals in the environment.

Summary of Urine Analysis of Atrazine and 2,4-D

Atrazine was only applied by aerial spray and 2,4-D was almost exclusively applied by aerial spray in forestry operations. For that reason, there is a high likelihood that human exposure to these chemicals, as detected in urine analysis, was caused by drift from aerial spray applications. The OHA Exposure Investigation (Oregon Health Authority, 2013) reached a similar conclusion. They found that concentrations of 2,4-D and atrazine in post-application urine samples increased when compared to baseline samples.

The detections of atrazine are not readily explained by private use on residential property because atrazine is a restricted pesticide not available to non-licensed applicators. Atrazine detections cannot be attributed to state, county or forestland roadside sprays because it was not used in those applications.

The detections of 2,4-D seem to correlate with increased aerial sprays in spring months. Detections in fall urine samples raise concerns about bio-persistence because 2,4-D was not aerially sprayed in fall months and was not widely used on roads. Pesticide records for agricultural lands were not available for this analysis.

Aerial spraying presents concerns for human and environmental health because it is prone to drift to streams and rural residential areas. Page 28 of the OHA Highway 36 Corridor Exposure Investigation (Oregon Health Authority, 2013) states:

> *"... there is evidence suggesting that aerially applied pesticides in general and atrazine in particular, can move at least 2-4 miles away from the application site; therefore it is possible that local aerial atrazine applications contributed to the elevated levels of urinary atrazine metabolites detected in participants."*

The data shows an increase of both quantity of pesticides and number of acres sprayed. The repetitive seasonal patterns of spray would also be associated with more chemical accumulation and saturation in the environment. The increasing practice of applying herbicides by helicopter in a rough, steep terrain prone to unpredictable wind and precipitation is likely to result in more aerial drift. These three factors pose increasing risks for rural residents, endangered fish species and other aquatic life, and soil nutrients.

Looking at trends within the three-year window, the EIQ Analysis reveals more sprays per year, more reliance on atrazine and 2,4-D aerially sprayed, and spring sprays with atrazine and 2,4-D having the highest environmental impact. If these trends continue, the result will be an increased threat of bioaccumulation and human exposure.

Human Health Effects from Atrazine and 2,4-D

The literature on forestry pesticides is extensive and cannot be reviewed in this report. Numerous studies have looked at the health risk of herbicides. A limited selection of studies on atrazine and 2,4-D documenting the potential risk of human exposure to these herbicides can be found in Appendix C.

Human Rights Perspective

Beyond Toxics supports the view that residents of the Triangle Lake area (and other rural Oregon communities) have certain human rights that are violated by the nonconsensual exposure to pesticide sprays that invade their properties and their bodies. A report by Environment and Human Rights Advisory (Kerns, 2011) identifies 23 specific human rights norms that may have been violated by pesticide spraying in the Triangle Lake area. These including the following rights:

- right of all people to the highest standard of health
- right of all people to have personal security and safety on their own property
- state's duty to provide for the health of its citizens
- rights of children and pregnant women to special considerations
- right to a healthy environment
- right to an effective remedy

An executive summary of this report is attached in Appendix D.

A human rights perspective provides a dimension critical to modern day policy decisions. Under the corporate profit model, cost to human and environmental health is borne by individual victims and society, with no compensation for loss and a lack of corporate accountability

Kerns (2011) eloquently expresses the moral obligations of governments to protect the health and safety of their citizens:

> *"… human rights norms represent basic moral minimums, a moral floor beneath which state and state-regulated behaviors must not sink. If*

> *civil laws represent hard legal boundaries outside of which certain behaviors are not legally permissible, human rights standards represent hard ethical boundaries that define the outer limits of morally permissible behaviors."*

Human health was a primary factor in modifying chemical practices by federal agencies in the 1980s. The U.S. Forest Service and U.S. Bureau of Land Management, agencies that manages hundreds of thousands of acres of forestland throughout Oregon and also within the study area, eliminated the use of pesticides for managing logging operations.

Water Quality and Salmon Habitat

Salmon and Steelhead Habitat

The Oregon Department of Fish and Wildlife (ODFW) has identified approximately 170 miles of Coho and Chinook salmon and steelhead habitat within the study area (Figure 15). The Coho are listed as threatened on the federal endangered species list. The threatened designation means this species is likely to become extinct in the near future, unless the ecosystem necessary for survival is restored. Consequently the federal government identified salmon streams in the study area as critical habitat. The Coho's critical needs to survive in this freshwater habitat are cold water, habitat structures such as downed logs, gravel for spawning that is free of fine sediment and healthy populations of macroinvertebrates for food. Federal and state agencies have enacted laws to protect the habitat of endangered and threatened species.

Steelhead are a migratory species of rainbow trout. Their life cycle is similar to salmon; however after spawning they do not necessarily die. Steelhead may return to the ocean and migrate to spawn again. They are a species of concern in the study area, which means the species is at risk for survival.

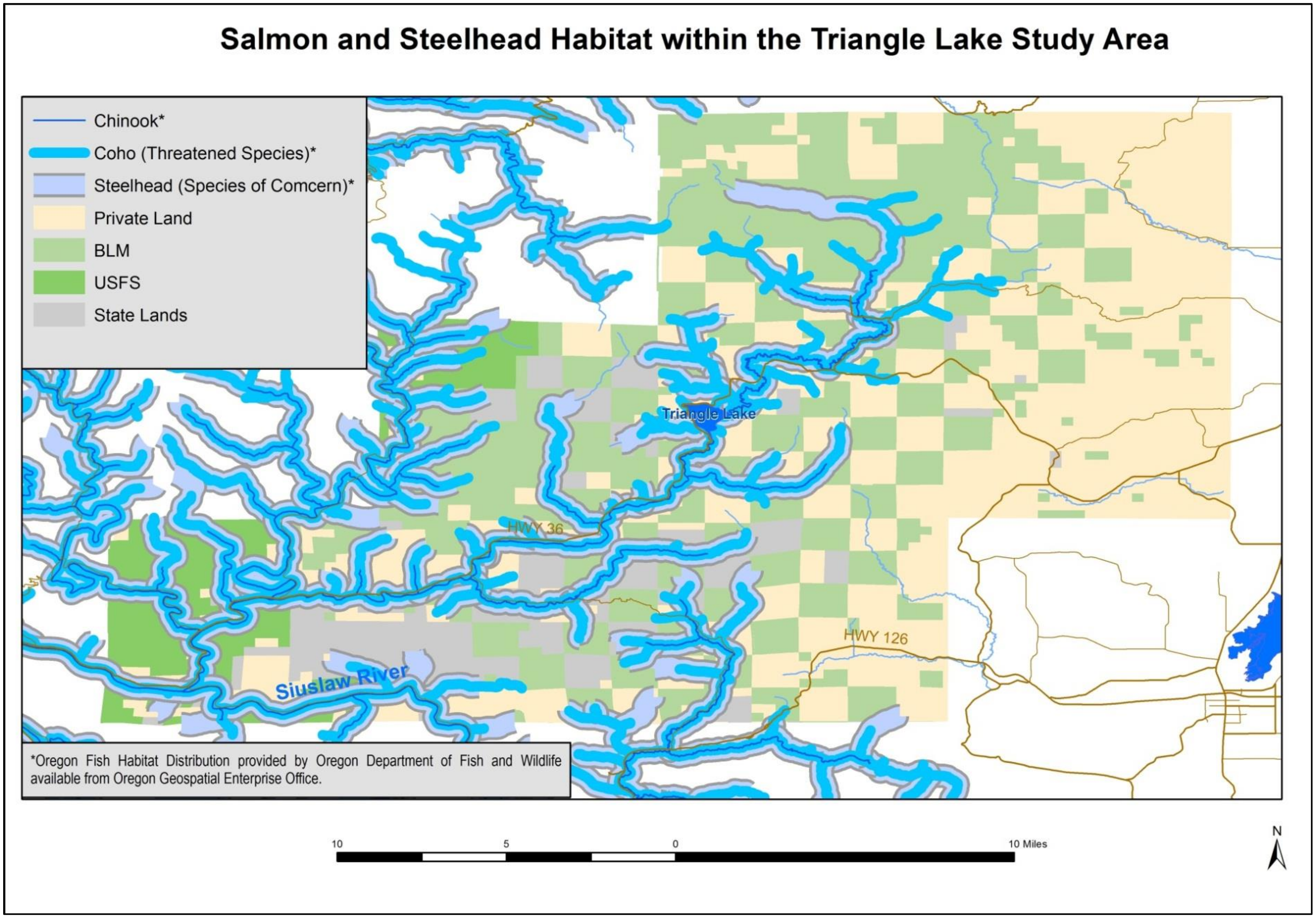

Figure 15. Salmon and steelhead streams identified by Oregon Dept. of Fish and Wildlife

Chemical Policies Regarding Fish Protection

The Oregon Forest Practices Act (FPA), administered by the Department of Forestry, governs the practice of pesticide applications on forestland. The Oregon Department of Agriculture has ultimate authority to regulate pesticides.

Chemical rules of the Forest Practices Act require applicators to avoid aerial herbicide applications within 60 feet of fish streams or drinking water streams, and avoid ground-based applications (backpack or pressurized sprayers) within 10 feet of those streams (Oregon Department of Forestry, 2009). The Oregon Forest Practices Act does not require buffer zone protections for headwater and small tributary streams that flow into salmon habitat (Figure 16). Although these streams may not be large enough to support fish, they do have an important hydrological connection to downstream fish streams.

Helicopter operators are not required to submit flight pattern data from their flight log to the Department of Forestry to verify that buffer zones are being observed.

Figure 16. Headwaters of Swartz Creek (in Lake Creek watershed), a typical clearcut unit that is aerially sprayed.

For some restricted pesticides, the Forest Practices Act is more lax than the EPA label. In such situations, the FPA requires the applicator to follow federal pesticide label restrictions. Using multiple sources to determine current regulations can create inconsistency and non-compliance.

A case in point is atrazine, the second most common product (measured in pounds) applied in the study area. This herbicide is regulated as a restricted product because of concerns about water contamination and toxicity to aquatic species. Legal restrictions are found on federal EPA product labels as well as special announcements on the Oregon Department of Agriculture website. The federal EPA label restrictions for atrazine are significantly different from state regulations. Table 8 highlights these differences (Oregon Department of Agriculture, 2009).

Table 8. Comparison of federal and state atrazine restrictions

Water Bodies	Federal EPA Label Restrictions	Oregon Forest Practices Act Restrictions
Fish streams (Type F)	66' Aerial Spray	60' Aerial Spray
	66' Ground Spray	10' Ground Spray
Non Fish streams (Type N), with surface water present	66' Aerial Spray	0' Aerial Spray
	66' Ground Spray	0' Ground Spray
Confluence of flowing streams	66' Aerial Spray	Not identified
	66' Ground Spray	Not identified
Points where surface water run-off from adjacent hillsides enters a stream	66' Aerial Spray	Not identified
	66' Ground Spray	Not identified
Lakes and reservoirs, estuaries, bogs and wetlands	66' Aerial Spray	60' Aerial Spray > 8 acres
	66' Ground Spray	10' Ground Spray > 8 acres
Non Fish-bearing streams (Type N), with no surface water present	0' Aerial Spray	0' Aerial Spray
	0' Ground Spray	0' Ground Spray

The Oregon Forest Practices Act does not require a review of the operator's written plan to determine if it follows federal EPA label requirements. The timber operator submits a notification with a written plan to the Oregon Department of Forestry. Written plans appear to be generic. Operators are not held responsible to adapt the written plan to fit the needs of each location. Consequently, they do not specify compliance with EPA pesticide product labels. For example, there is no indication on the written plans that non-fish streams with surface water present are receiving the required 66 foot no-spray buffer when atrazine or a tank mix containing atrazine is used. Spray application records reviewed for this report did not indicate that pesticide applicators obeyed legal restrictions for atrazine listed in Table 8.

The State Forester may make comments on the written plan, which are advisory only. Department staff is not authorized to approve or make changes to the written plan. In many cases the State Forester’s signature is missing from the notification document. The lack of agency oversight prevents assurance that laws and regulations are followed.

The difference between federal and state requirements for atrazine is one example of uncertainty in compliance with regulations that protect water quality. Under the FPA, agency review, operator documentation and monitoring are absent. Aligning FPA requirements with federal requirements would reduce potential violations of the law and help protect Oregon’s water quality.

Spray Data Analysis for Aquatic Habitat

Within the study area, aerial spray units were often adjacent to salmon and steelhead habitat streams. As discussed above, there was an increase in acres sprayed from 2009 to 2011. This resulted in an increase in miles of riparian and salmon habitat that were impacted. Using GIS mapping, the number of stream miles within and adjacent to aerial spray operations was calculated (Table 9).

Table 9. Miles of streams within 60 feet or less of aerial spray units per year

Year	Miles of Designated Salmon/Steelhead Habitat Streams	Miles of All Streams (including headwaters, tributaries, and salmon/steelhead habitat)
2009	0	8.2
2010	2	8.9
2011	2.2	16.2

Approximately two miles of protected salmon habitat were adjacent to aerial spray units in 2010 and 2011. It should be noted that the mileage is not contiguous; it represents small sections of streams distributed throughout the study area. The data in Table 9 are a snap shot in time, looking at only three years of ongoing spray activities. Over the long term, if we extrapolate this data ten or more years back in time, and into the future, numerous miles of salmon habitat streams are subjected to aerial sprays. The data suggest a chronic impact to endangered species and water quality. See Appendix E for a small sample of literature that cites chronic and synergistic pesticide impacts to fish.

The majority of stream miles in riparian areas listed in the last column of Table 9 are headwater and tributary streams. The tributary streams that flow year-round have direct hydrological surface water connections to the downstream salmon habitat. As indicated in Environmental Impact Quotient ratings found in Figure 12, Figure 13 and Figure 14, aerial herbicide spraying appears to have a greater environmental impact during spring months. Spring is also when young, vulnerable salmon and steelhead are emerging from gravels and feeding on microorganisms and aquatic plants.

Headwaters are often seasonally dry during the summer and early fall. Under the Oregon Forest Practices Act, these non-fish streams have no protective buffer, which means chemicals can be applied within the stream channel. Pesticides can persist in soil and be easily transported through leaching and runoff. This is a concern in the fall, when the first large rain events create runoff in these newly clearcut units, consequently increasing the amount of chemicals flowing into downstream salmon habitat. The ODFW lists spawning in the area from October 15 through May 15 (Oregon DEQ, 2003b). This means spawning occurs at the same time as the downstream transport of pesticides following the first rains.

Pesticides commonly reported in salmon habitats may pose a more important challenge for species recovery than previously anticipated for some of the following reasons:

- Bio-persistence in the environment
- Synergistic interactions from tank mixes
- Underestimations of impacts to food sources (e.g., microorganism and invertebrates)
- Effects to other aquatic species (e.g., resident fish and amphibians)

Summary of Analysis for Aquatic Habitat

The number of stream miles aerially sprayed has doubled over the three-year study period. The repeated use of pesticides suggests a chronic impact to endangered species and water quality. State policy allows non-fish tributaries to be aerially sprayed without the protection of a buffer. These headwaters and tributaries have a direct effect on fish streams through surface and ground water. The hydrological connections provide a pathway for chronic exposures to threatened and endangered species. Spraying headwaters and tributaries fails to protect downstream fish habitat. Oregon's Forest Practices Act lacks guidance and regulations to prevent the decline of the watershed and the aquatic species it supports.

Fish Creek Case Study

Fish Creek is a tributary to Lake Creek that flows into the Siuslaw River (Figure 17). The Oregon Department of Fish and Wildlife designated Fish Creek as a Core Cold Water Salmon Habitat Stream. The attributes of a Core Cold Water Habitat include ample gravel for spawning free of fine sediments, cold, clean and well-oxygenated water.

The designation "Core Cold Water Habitat" stresses the importance of Fish Creek to the threatened Coho salmon in the study area. This unique designation warranted using Fish Creek as a special Case Study to look at logging patterns and chemical use on a smaller scale.

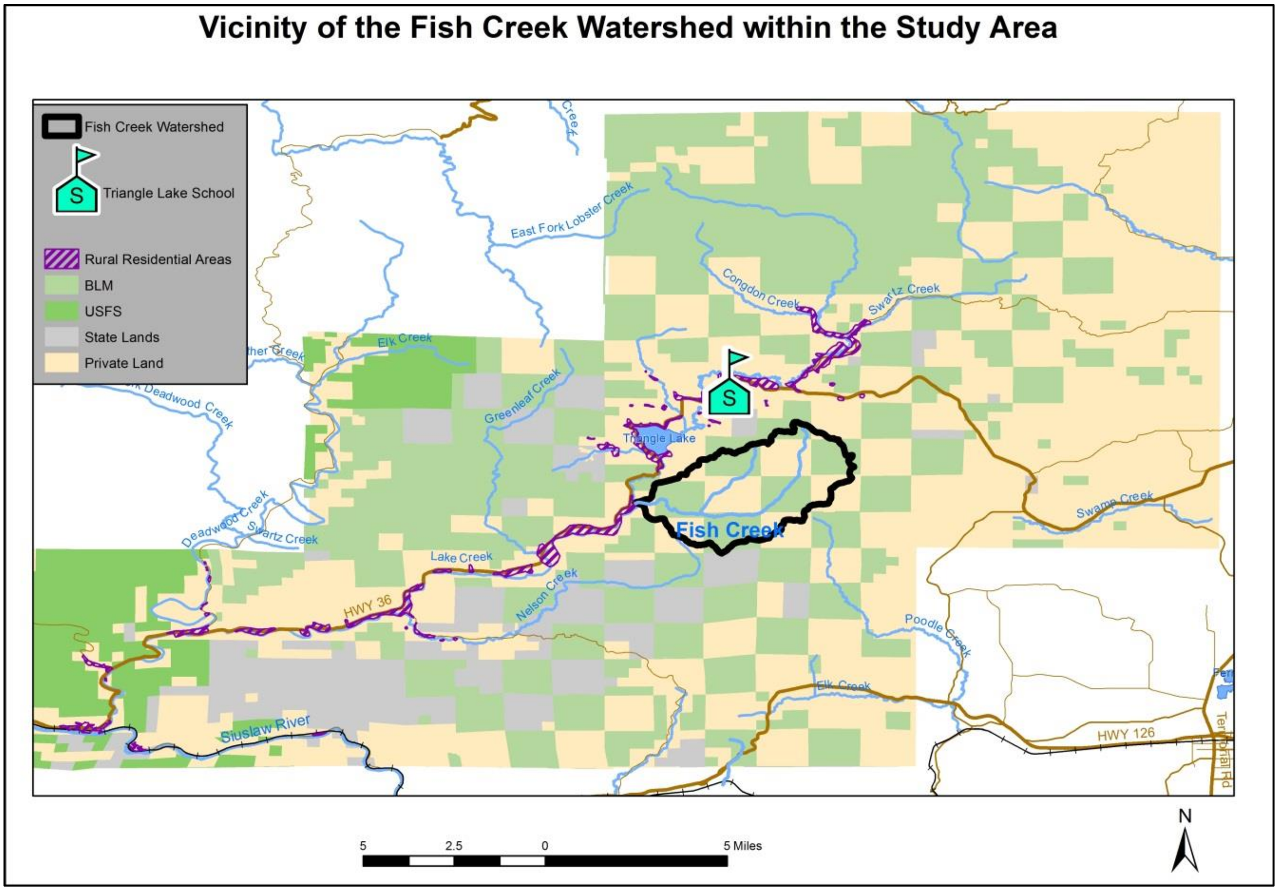

Figure 17. Location of the Fish Creek watershed

Similar to land ownership in the entire study area, approximately 43% of the Fish Creek watershed is on private land, 56% is managed by the BLM and 1% is on state land.

Private industrial forestland operations are the sole source of aerial pesticide sprays. Looking at the entire 184,320-acre study area, approximately 3% of private forest land was aerially sprayed. However, within the smaller 5,320-acre Fish Creek Watershed, the percentage of private land sprayed with pesticides was significantly higher. Approximately 11% of private forest land was aerially sprayed in 2009 and 2010. Acreage sprayed increased to 17% in 2011 (Table 10). When comparing the Fish Creek case study to the entire study area, Fish Creek has a greater percentage of acres sprayed per total acreage. The comparison is noteworthy in consideration of Fish Creek's designation as a Core Cold Water Salmon Habitat and the dense network of streams, tributaries and headwaters in this watershed.

Table 10. Fish Creek watershed private land aerially sprayed annually

Case Study - Fish Creek Watershed		
Year	**Aerial Spray Acres**	**% Land Aerially Sprayed***
2009	250	11%
2010	251	11%
2011	394	17%

*Does not include ground sprays or roadside sprays on logging roads

In this Core Cold Water habitat, the number of acres aerially sprayed increased 58% from 2009 to 2011. Figure 18 displays areas sprayed from 2009 through 2011. Most units were aerially sprayed at least two out of three years. The older clearcuts in the background aerial photo indicate there is a high likelihood that these acres of private land were also sprayed prior to 2009.

Figure 18 shows the location of streams within the aerially sprayed units. Highlighted in purple are portions of the units that were aerially spayed adjacent to federally listed threatened Coho salmon habitat. The proximity of aerial herbicide sprays to the designated Core Cold Water Habitat and its tributaries is evident. One highlighted area demonstrates that, even if a salmon stream is flowing through federal land, herbicide spraying on adjacent private land can still be quite close to that stream.

Figure 18 also displays headwater and tributary streams that are located within aerial sprayed units. These streams are highlighted in bright green. Most of these streams are non-fish bearing and therefore the spray applicator was not required to leave a chemical buffer.

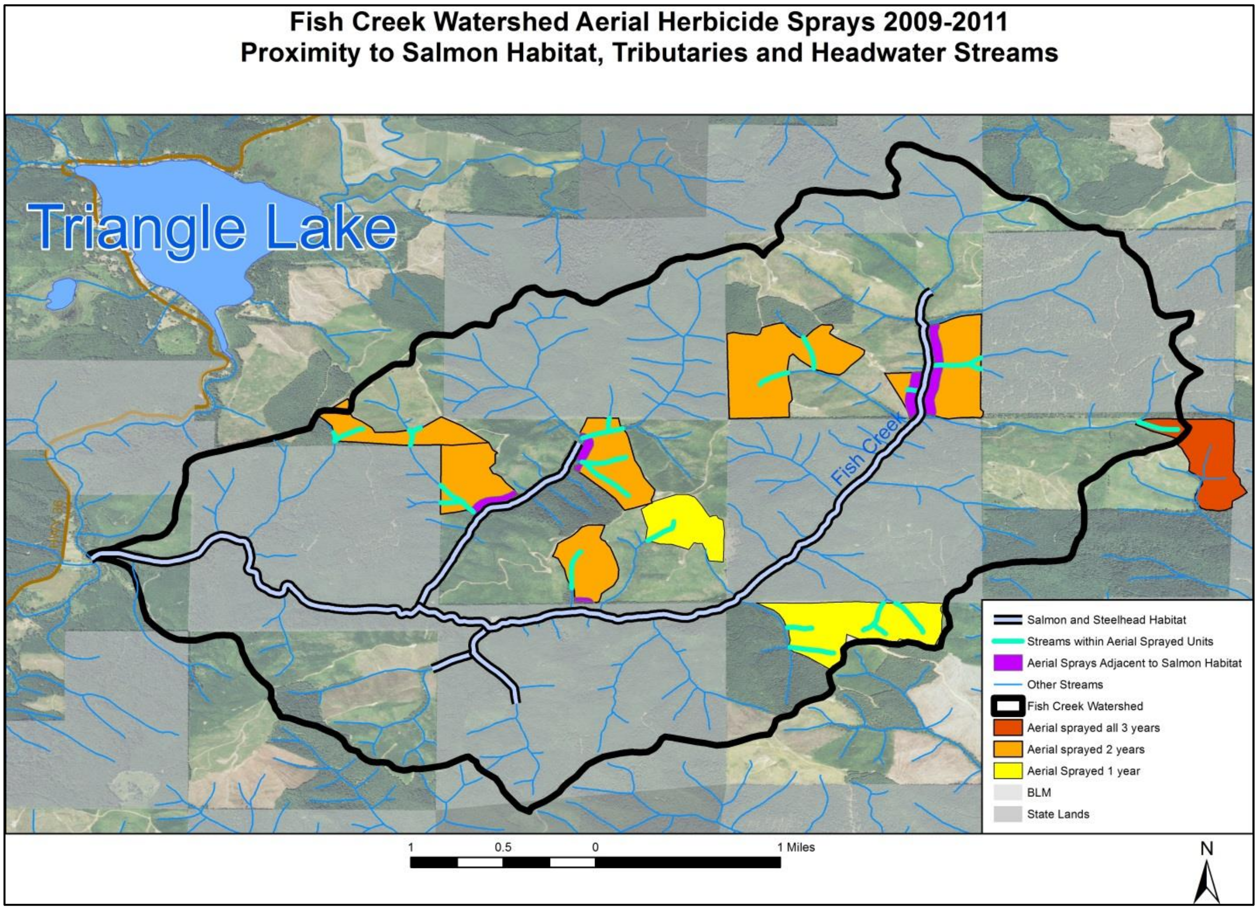

Figure 18. Units aerially sprayed multiple years and proximity to salmon habitat and headwater/tributary streams

Figure 19 is similar to the previous figure. However, Figure 19 lists the season and year the units were aerially sprayed, along with the chemical tank mixes. Codes for the chemical labels are listed in the top left corner within the map.

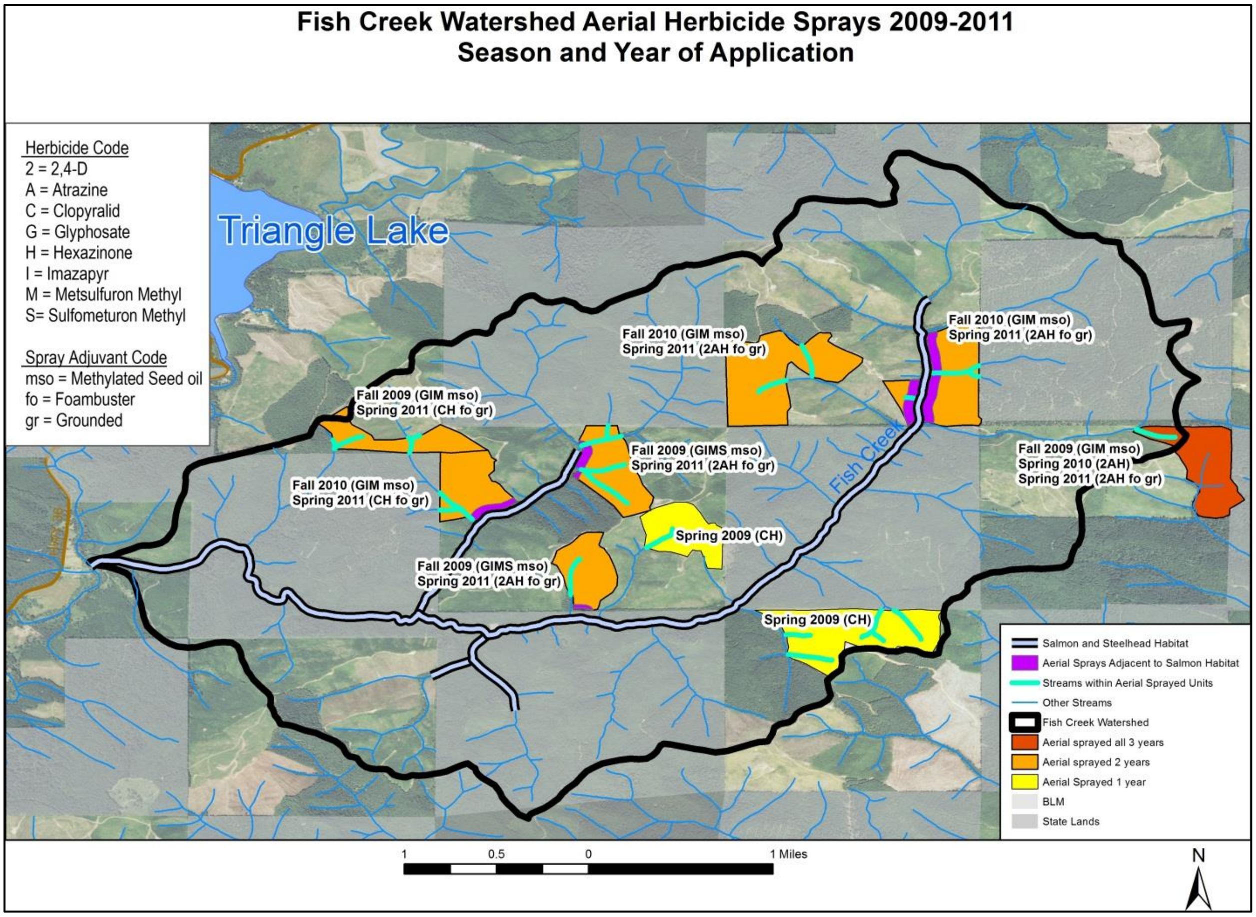

Figure 19. Chemicals aerially sprayed by season, year and proximity to salmon habitat and headwater/tributary streams

Pesticide spray records show that tank mixtures including 2,4-D and atrazine are aerially applied over tributaries flowing into fish-use streams and within 60 feet of the specially designated Fish Creek. These two chemicals have a higher Environmental Impact Quotient rating (refer to the section "Environmental Impact Quotient"). This case study on chemical use in Fish Creek, a Core Cold Water salmon habitat, shows that the Oregon Forest Practices Act does not require modified choices of practices and/or chemicals to protect sensitive species.

Summary of Fish Creek Case Study

Several findings indicate that the Oregon Forest Practices Act does not protect federally listed threatened Coho salmon habitat, as well as all other native salmon and trout species.

- Fish Creek Watershed had between 11% to 17% of private forestland aerially sprayed, compared to an average of 3% in the entire study area.
- In this Core Cold Water habitat, the number of acres aerially sprayed increased 58% from 2009 to 2011.
- Spray application data indicate that aerial sprays occur over headwaters and small tributary streams flowing into unique and protected salmon habitat.
- Tank mixes of chemicals may have lethal or sub-lethal impacts to aquatic organisms (refer to the section "Tank Mixes").
- Aerial sprays typically occur when salmon spawn in fall and when young salmon emerge in spring.
- The industry practice of conducting repeated seasonal spraying on the same land increases the potential for accumulation of chemicals in soil and in surface and ground water.
- Records show a pattern of repeated aerial herbicide sprays of toxic chemicals on the same ground, over the same tributaries and adjacent to salmon streams in an area with listed fish and a state-designated Core Cold Water salmon habitat.

Water Quality Sampling Results

In April 2011, a group of residents decided to test water in Triangle Lake-area streams for the presence of forestry herbicides. The equipment deployed was a Polar Organic Chemical Integrative Samplers (POCIS). These samplers were developed by the U.S. Geological Survey to be immersed in streams and collect contaminants over weeks or months. Deployment and retrieval dates are in Table 11. The Oregon Department of Environmental Quality approved the data based on a submitted quality assurance project plan.

POCIS samplers were placed at five sites in the Lake Creek Watershed, four in public water and one in a private spring (Figure 20). Fish Creek was chosen because the Oregon Department of Fish and Wildlife designated Fish Creek, a tributary stream to Lake Creek, as Core Cold Water Habitat.

Table 11. POCIS water sampling data

Site No.	Site Name	Date Deployed	Date Retrieved	Atrazine Detected	Hexazinone Detected	Desethyl Atrazine (metabolite) Detected
1	Fish Creek near mouth	04/15/11	05/15/11	X	X	X
2	Lake Creek above Fish Creek	04/15/11	05/15/11	X	X	X
3	Congdon Creek near mouth	04/23/11	05/21/11	X	X	
4	Private spring to Congdon Creek	04/23/11	05/21/11			
5	Nelson Creek below Almaisie	06/03/11	07/03/11		X	

There were several aerial sprays in the Fish Creek Watershed before the placement of POCIS samplers. Aerial operations shown in pink in Figure 20 were sprayed between April 30 and May 15, 2011, one to 17 days before POCIS samplers were placed in water. Spray records show that four out of six units were aerially sprayed with a tank mix of hexazinone and atrazine before POCIS samplers were placed. All thirteen units sprayed during POCIS deployment used atrazine and/or hexazinone.

Sprays that occurred during water sampling are shown in darker red in Figure 20.

All nineteen aerial sprays could have contributed to pesticide detections in streams. Sites 1, 2, 3 and 5 (Table 11) are Oregon state waters. Atrazine and hexazinone were detected in POCIS surface water samples in spring 2011, meaning that these pesticides were present in these public waters. The private spring (Site 4) had no pesticide detections.

Fish Creek near mouth, Site 1: The highest levels of hexazinone and atrazine and its metabolites were found in the Fish Creek sampler before it joins with Lake Creek. Applications before and during deployment could have contributed to detections in Fish Creek. Any or all of the contamination pathways are possible; in other words, the pesticides came from direct spray of unbuffered streams, runoff, re-volatilization and/or drift through air.

Lake Creek above Fish Creek, Site 2: Hexazinone, atrazine and its metabolites were found in Lake Creek above the confluence with Fish Creek. Site 2 is outside the Fish Creek drainage. As shown in Figure 20 the only aerial sprays upstream of sampling Site 2 were high up in the watershed and well above Triangle Lake, so direct spray or runoff are not likely pathways. Furthermore, the sprays occurred during the time of POCIS sampling, making it virtually impossible for run-off to cover the distance (which includes Triangle Lake) within the sampling period. That leaves drift and re-volatilization through air as the most likely pathways for pesticides found in the Lake Creek sampler.

This is especially true for atrazine which is a restricted use product in Oregon, which means that it is not sold to non-licensed applicators (i.e., homeowners).

The closest aerial sprays to the Lake Creek sampler were one mile away for hexazinone and two miles for atrazine. The farthest spray operations that used these chemicals were 7.7 miles away from the Site 2 Lake Creek sampler. This suggests that hexazinone reached POCIS samplers from sprays one to 7.7 miles away; detections of atrazine could have been caused by sprays that occurred 2 to 7.7 miles away.

Congdon Creek near mouth, Site 3: Atrazine and hexazinone were detected in Congdon Creek. No aerial sprays occurred upstream in the Congdon Creek drainage from 2009 to 2011 (refer to Figure 7). In 2011, the closest aerial sprays occurred 1.8 miles to the west and 3.6 miles to the east. Data suggest that detections were from drift and re-volatilization. The data make a strong case for drift based on application records.

Nelson Creek below Almaisie, Site 5: Hexazinone was detected in Nelson Creek. There were no aerial sprays applying hexazinone in the Nelson Creek drainage from 2009 to 2011. Several aerial sprays applied hexazinone in 2011 within three to five miles of the sampler. These sprays occurred on May 9, 10 and 12, approximately three weeks before the sampler was placed. The data suggest re-volatilization may have been pathway.

In assessing ground spray data, only one spray occurred close to samplers. This spray occurred April 27, 2011, during the water-sampling period. It contained a tank mix that included hexazinone and was located adjacent to Lake Creek less than one-half mile downstream from samplers in Fish Creek and Lake Creek (Figure 20). There is a slim possibility that this spray could account for the hexazinone, but detection would be the result of drift and not runoff because it occurred downstream. No ground sprays in the entire study area for the 2009 to 2011 used atrazine.

These chemicals negatively affect aquatic habitats. While the literature on the aquatic impacts to fish is extensive, Appendix E serves as a basic introduction to research on the topic.

Summary of Water Quality Analysis

Detections of hexazinone and atrazine in fish habitat streams indicate that pesticides are entering aquatic environments. Aerial sprays were applied just before and during the deployment of POCIS water samplers. The following pathways could contribute to detections of hexazinone, atrazine and its metabolites:

1. direct spraying of the small tributaries where no buffers are required;
2. runoff of pesticides or sediment particles with pesticide attached (adsorbed) to them;
3. movement through ground water;
4. deposition due to drift and re-volatilization through air.

All of the above pathways could account for detections of atrazine and hexazinone in Fish Creek. The data suggest that drift and re-volatilization through air are the most likely pathways for pesticides found in Lake Creek and Congdon Creek.

Atrazine is a restricted chemical and must be applied by licensed operators in commercial settings. Hexazinone does not have this restriction; however the primary uses of hexazinone are for forestry and Christmas tree farms.[13] There is a likelihood that atrazine detection is from aerial industrial forest timber sprays. The ability to pinpoint the sources of hexazinone is less conclusive because herbicide records for private and agricultural uses are unavailable to the public. Nonetheless, industrial forestry frequently apply hexazinone by aircraft, thus aerial spray drift is likely a major source.

[13] Christmas tree farms are regulated as an agricultural practice. Spray records are not available for agricultural uses.

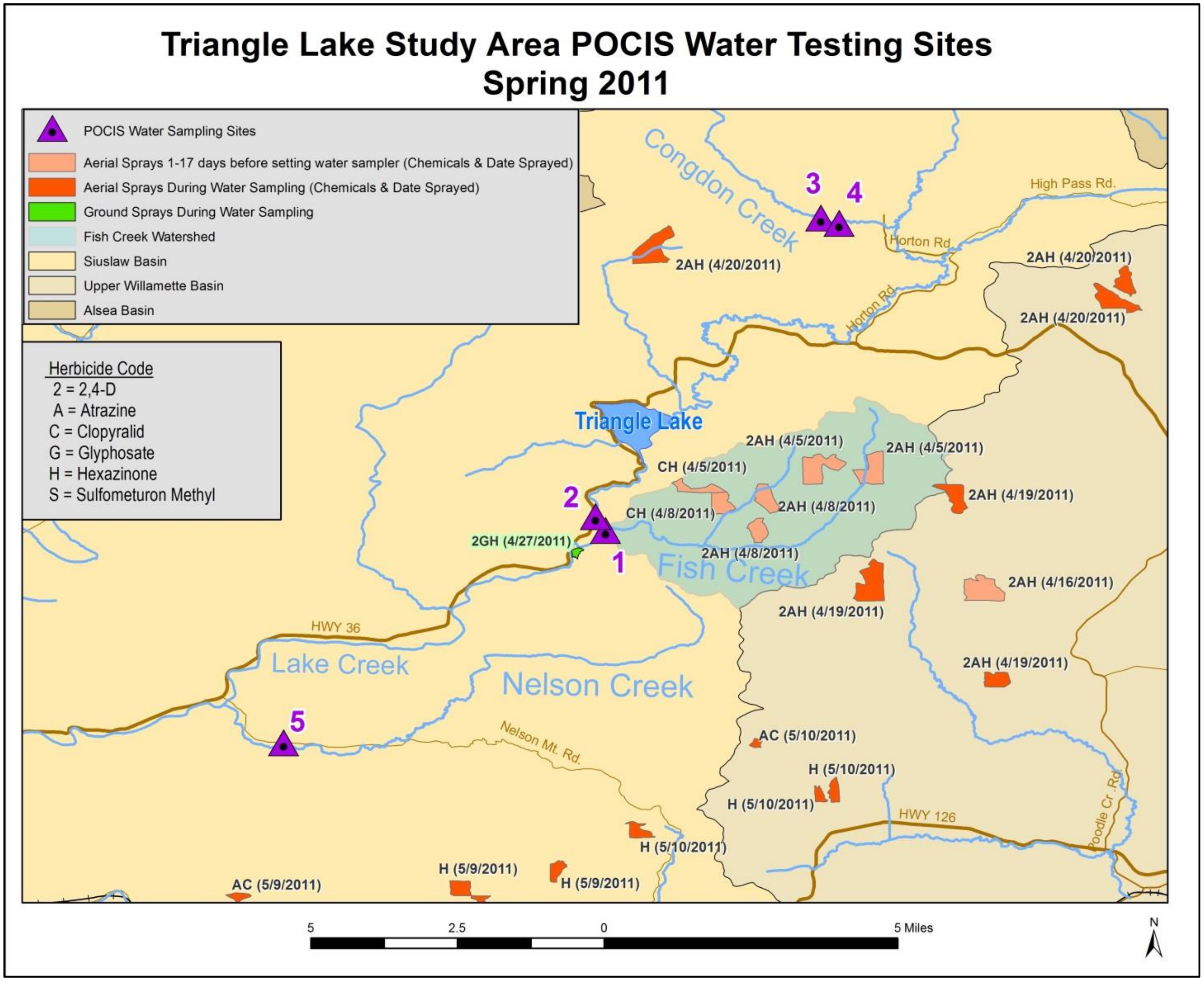

Figure 20. Water sampling sites and spring 2011 sprays.

Court-Ordered Buffers for 2,4-D

On January 22, 2004, the United States District Court issued an order establishing pesticide buffer zones. Buffer zones are areas adjacent to certain streams, rivers, lakes estuaries and other water bodies. The court order required a 300-foot buffer for aerial spray and a 60-foot buffer for ground spray along Pacific salmon streams for several pesticides because these chemicals may jeopardize the survival of threatened salmon species (US EPA, 2004). Two of these chemicals were used in the study area, 2,4-D and tryclopyr BEE. The court order was lifted after the National Marine Fisheries Service (NMFS) released a Biological Opinion on June 30, 2011 (NOAA Fisheries, 2013). The U.S. Environmental Protection Agency (EPA) was given a year to implement the restrictions. As of this report, the EPA has not implemented the protections.

Looking specifically at 2,4-D, a chemical identified in the court order, Figure 21 identifies four areas of aerial spray that may have occurred within 300 feet of a salmon and steelhead stream (Spray Application Records 2011-781-00151 units 1, 5, 8 and 9). Three of these sprays were in Fish Creek Watershed, an Oregon Department of Fish and Wildlife-designated Core Cold Water Habitat Stream. Under the court order from 2004 through June 30, 2011, aerial spray containing 2,4-D could not be applied closer than 300 feet from a salmon stream.

The four aerial sprays in Figure 21 occurred during April 2011 (while the court order was still in effect). The written plans were submitted to the Oregon Department of Forestry as part of the notification. The written plans and spray application records for these units identified the streams as protected resources, but neither of them acknowledged the court-ordered precautions. Thus, it is unclear that the streams received protective measures.

Unit 9 was unique because it was in close proximity to Fish Creek. The creek flows through BLM land. The stream was not identified as a protected area on the spray record because the private timber land boundary is more than 60 feet from the stream channel. Nonetheless it was within the 300-foot buffer required by the court.

Spray records indicate that aerial spray of 2,4-D occurred adjacent to salmon streams during a time when buffers were required. This draws attention to the lack of monitoring, poor enforcement of the law and inability of the Oregon Department of Forestry to evaluate, comment and modify spray notifications and written plans.

Neighboring states affected by the court order took action to enforce the restrictions. For example, the Washington Department of Natural Resources (2009) timber harvest manual clearly informs timber operators of this restriction:

A recent federal court ruling has mandated a minimum 300' buffer on some salmon-bearing streams in the State of Washington. This ruling increases buffer size (beyond Forest Practice Rules) on streams when using forest chemicals in certain areas. Check the Washington Department of Agriculture website or call the Department of Agriculture at 1-877-301-4555 to see if you may be affected.

In Washington state, the spray application would have been reviewed, modified if necessary for approval and possibly undergo an environmental protection assessment.

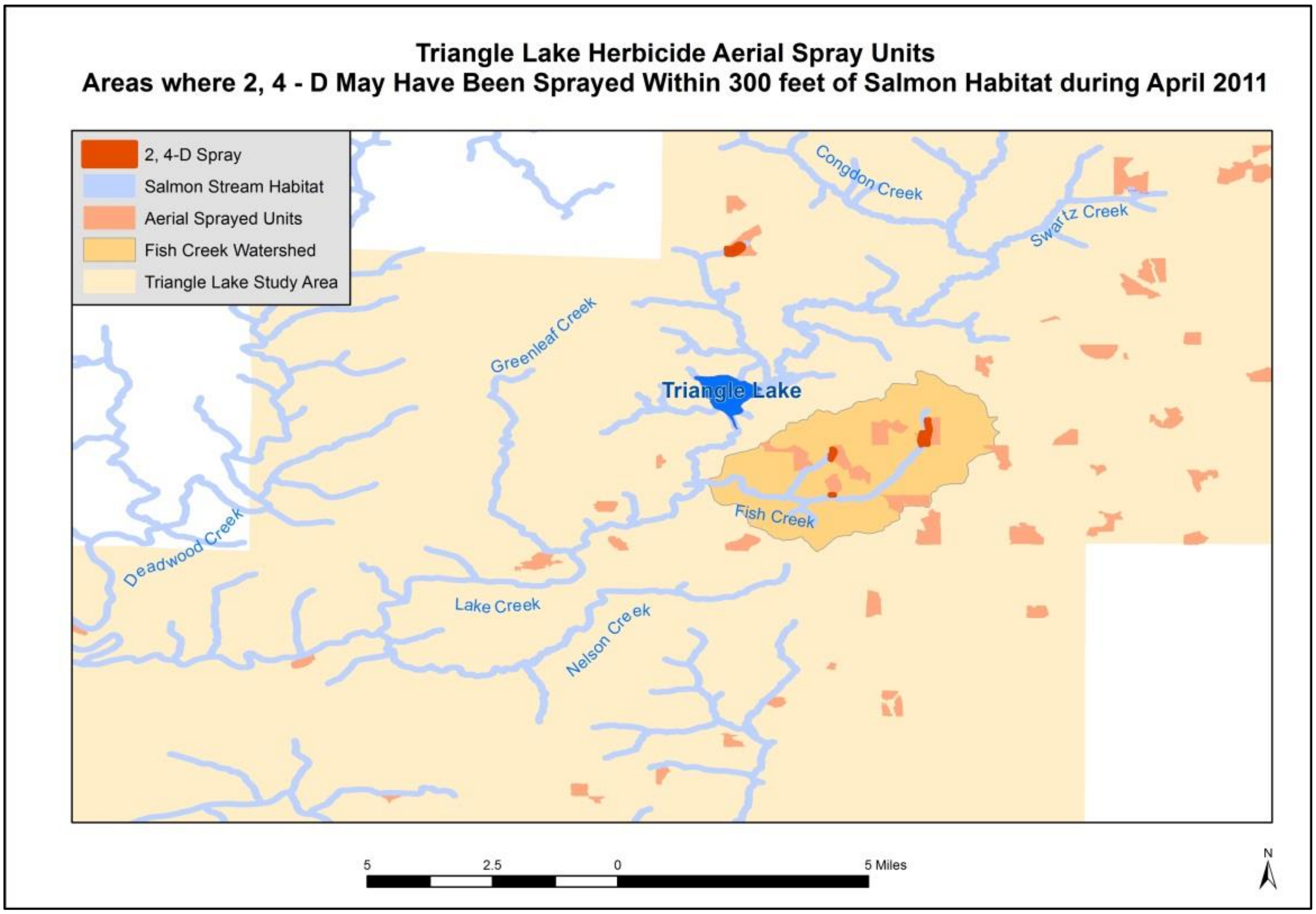

Figure 21. 2,4-D Aerially sprayed close to salmon streams in April, 2011 when the Court-ordered buffer zones were in effect.

Comparison of OR-WA-ID State Forest Practices Acts

Oregon, Washington and Idaho are neighboring Pacific Northwest states where geography, temperature, climate and forestry ecosystems have many common elements. Major industrial timber companies have land holdings and offices in these states and are accountable to their forestry practices laws.

Table 12 compares key requirements of the Washington, Idaho and Oregon Forest Practices Acts. There are significant differences in the intent and regulatory scope with regard to protecting water resources, riparian areas, public health and endangered species. Different approaches are also taken to ensure the public's right to know which chemicals are in the environment and being applied near their homes, schools and communities.

Comparison of Oregon and Washington Rules

Washington's Forest Practices Act has specific regulations to protect streams. No-spray buffers depend on size of the stream channel, tree growing conditions, height of the aircraft, nozzle type, wind directions and weather conditions (Washington State Legislature, 2003) (Washington Department of Natural Resources, 2009).

Fish Streams-Aerial and Ground Sprays: For units adjacent to a fish stream, in similar growing conditions as the study area, the chemical buffer zone can range in size:

- 100 to 150 feet for fish streams, under favorable weather conditions
- Up to 325 feet for fish streams, under less favorable weather conditions and when flying at a height of 51 feet or above.
- The buffer widths for ground spray are the same as aerial spray, 100 to 150 feet.

Along fish-bearing streams, the Oregon Forest Practices Act requires 60-feet buffers for aerial spray and 10-feet buffers for ground spray. The required buffer widths do not increase to account for flying height or weather conditions.

Non-Fish Streams: For non-fish perennial streams and headwater springs within aerial spray units, Washington requires 50 to 100 foot buffers (Washington Department of Natural Resources, 2009). All surface water is protected with a no-spray buffer. Intermittent streams with no surface water present at the time of spray do not require a buffer.

Under Oregon’s rules surface water is not protected. Non-fish streams do not require protective buffers, which includes seasonal streams, perennial streams, and headwater springs.

<u>Drinking Water, Ground Water, Residences and Agricultural Sites:</u> Washington requires buffer protections for domestic drinking water, residences and agricultural lands. Oregon does not require buffers to protect any of these vulnerable sites. The 1978 updates to the Oregon FPA established buffers around residential homes. However, these required buffers were repealed during a rule review between 1995 and 1997 (Oregon Department of Forestry, 2011).

Drinking and ground water protections are outlined in Washington Administrative Code. The rules require a detailed analysis of the chemical’s potential for an environmental impact. Depending on the toxicity of the pesticide and the level of protection for water resources, the chemical application may trigger a Class 4 State Environmental Protection Act (SEPA) Special Review (Washington State Legislature, 2005).

Washington bans twelve pesticide products for use in ground water protection areas (Washington State Legislature, 2002). The pesticides atrazine and hexazinone are included in this list. These pesticides are commonly used in Oregon forestry management and both were detected in the POCIS water sampling study that is discussed above in this report (Table 11).

<u>Agency Oversight and Public Input:</u> A major difference between the two states is the regulatory agency’s ability to evaluate and respond to timber operation plans. The Washington’s State Environmental Protection Act (SEPA) emphasizes the value of environmental health and protection as part of forestry practices. The Act creates opportunities for thorough agency review and public comment. Under Washington’s forest policy, timber operators are required to complete a Forest Practices Application, which is reviewed by state agency staff. During the review, the application is posted on a website and the public can access and comment upon the proposed forest activities. This review includes pesticide active ingredients and maps of spray locations (Washington Department of Natural Resources, 2001).

In contrast, Oregon does not require an application process. Instead of an application, the timber operator files a spray notification that alerts state foresters that a chemical spray operation will be conducted. An accompanying written plan is required only near protected resource sites. Without an application procedure, the state agency has no authority to modify a written plan or spray notification as long as it appears to meet the Oregon Forest Practices Act. *“Comments provided by the State Forester in response to a written plan are for the sole purpose of providing advice to the operator, timber owner or landowner…. Comments provided by the*

State Forester do not constitute an approval of the written plan or operation, nor does the lack of comments from the State Forester indicate compliance with state laws” (State of Oregon, 2013a).

The public must subscribe to the Oregon Department of Forestry notification system to receive paper copies of spray notifications. Dissimilar to Washington State, which provides an open system for public comment at all levels of review, Oregon has no option for official public comment within the Notification-Written Plan scenario. To provide a public comment and request a public hearing before the Board of Forestry, the party must be “*adversely affected or aggrieved*.” If a member of the public does file a request for a hearing with the Board of Forestry, they must be prepared to pay legal fees for the timber operator, timber owner or landowner if the outcome of the hearing is not in their favor. Furthermore, under OAR 527.700 8a(C)(b), if a stay of the operation is granted due to proof of irreparable injury, the Oregon Board of Forestry “*shall require the person requesting the stay to give an undertaking which may be in the amount of the damages potentially resulting from the stay, but in any event shall not be less than $15,000*” (State of Oregon, 2013b). These administrative rules suppress public participation because it is a significant financial risk to provide comment and protect their property.

Oregon requires application records to be kept for three years, compared to seven years in Washington. This restricts the ability of researchers and government agencies to analyze pesticide exposure concerns and environmental impacts.

Forest Practices Act Purpose: In Washington, the statement of purpose emphasizes resource protection and public access. The Act’s purpose is reflected in the official information provided to the timber operators and the public. Quoting from the Washington Department of Natural Resources website (2013a):

> *“The Forest Practices Application Review System (FPARS) streamlines the processing of Forest Practices Applications and improves the public's ability to review proposed forest activities … [using] document imaging technology, interactive geographic information system technology, and the Oracle database system to provide for collection of Forest Practices Application information, distribution of Forest Practices Applications for regulatory and public review, risk assessment of proposed Forest Practices Application activities, and archiving of Forest Practices Applications.”*

Below is the statement of purpose from each Forest Plan Act:

> **Washington Forest Plan Act Purpose:** The rules are designed to protect public resources such as water quality and fish habitat while maintaining a viable timber industry. They are under constant review through the adaptive management program (Washington Department of Natural Resources, 2013b).
>
> **Oregon Forest Plan Act Purpose:** The Forest Practice Act (FPA) states that Oregon public policy encourages economically efficient forest practices that ensure the continuous growing and harvesting of forest tree species and the maintenance of forestland for such purposes as the leading use on privately owned land, consistent with sound management of soil, air, water, fish and wildlife resources and scenic resources within visually sensitive corridors as provided in ORS 527.755 and to ensure the continuous benefits of those resources for future generations of Oregonians (ORS 527.630[1]) (Oregon Board of Forestry, 2012).

Comparison of Oregon and Idaho Rules

Idaho's Forest Practices Act has specific regulations to protect streams and vulnerable hazard areas (defined as a town, city, sub-division or densely populated area) (Idaho State Legislature, 1998).

Fish and Non-Fish Perennial and Intermittent Streams–Aerial and Ground Sprays:
For units adjacent to a fish stream, the chemical buffer varies:

- 100 feet for aerial spray for all fish and non-fish streams when surface water is present (Idaho State Legislature, 1998).
- 25-foot buffers for ground spray on all streams when surface water is present (Idaho State Legislature, 1998).

The Oregon Forest Practices Act requires 60-foot buffers for aerial spray along fish-bearing streams and 10-foot buffers for ground spray along fish-bearing streams. Oregon does not require any buffer for non-fish streams, including upstream headwaters and tributaries.

Drinking Water, Residences and Agricultural Sites: To protect human health, Idaho's Forest Practices Act follows the Idaho Pesticide & Chemigation Use & Application Rules (Idaho State Legislature, 1997/2000). In accordance with these rules, no aerial pesticide may be applied within one-half mile of a Hazard Area or 100 feet of a domestic water source. Oregon has no rules to protect residential areas.

Additionally there are specific restrictions on the use of 2,4-D near a Hazard Area.

- 2,4-D high volatile ester formulations may not be aerially sprayed within five miles of a Hazard Area or a susceptible crop.
- 2,4-D low volatile ester formulations may not be aerially sprayed within one-half mile of a Hazard Area or a susceptible crop.
- 2,4-D and dicamba amine and acid formulations may not be aerially sprayed within one-half to one mile of a Hazard Area under certain wind conditions, and may not be sprayed at all if the wind is more than 10 miles per hour.

Table 12. Comparison of Oregon, Washington and Idaho State Forest Practices Acts

Protection Area	Oregon State Forest Practices Act	Washington State Forest Practices Act	Idaho Forest Practices Act
Fish-Bearing Stream Buffer	60' Aerial Spray	100-150' Aerial Spray for Forests similar to the Coast Range of Oregon[14]	100' Aerial Spray
	10' Ground Spray	100-150' Ground Spray for Forests similar to the Coast Range of Oregon[14]	25' Ground Spray
Perennial Non-Fish Stream Buffer	0' Aerial Spray	50-100' Aerial Spray	100' Aerial Spray
	0' Ground Spray	25' Ground Spray	25' Ground Spray
Intermittent Non-Fish Stream Buffer	0' Aerial Spray	50-100' Aerial Spray with surface water 0' Aerial Spray with no surface water	100' Aerial Spray with surface water 0' Aerial Spray with no surface water
	0' Ground Spray	25' Ground Spray with surface water 0' Ground Spray with no surface water	25' Ground Spray with surface water 0' Ground Spray with no surface water
Wetland Buffer	60' Aerial Spray (when standing water is larger than ¼ acre at time of application)	25 – 200' Aerial Spray (depending on size of wetlands)	100' Aerial Spray (for areas of open water)
	10' Ground Spray	25' Ground Spray	25' Ground Spray (for areas of open water)

[14] Under less favorable weather conditions, buffer widths can be as wide as 325 feet from the stream.

Protection Area	Oregon State Forest Practices Act	Washington State Forest Practices Act	Idaho Forest Practices Act
Domestic Water Supply	60' Aerial Spray	200' Aerial Spray & triggers Class 4 SEPA Review	100' Aerial Spray
	10' Ground Spray	100-150' Ground Spray	25' Ground Spray
Ground Water Protection Areas	None	Vulnerable ground water areas trigger a Class 4 SEPA Review; **Chemicals Banned:** Atrazine, Bromacil, Dcpa, Disulfoton, Diuron, Hexazinone, Metolachlor, Metribuzin, Picloram, Prometon, Simazine, Tebuthiuron	None
Buffer next to Residences	0' Aerial Spray	200' Aerial Spray	2,640' (0.5 mile) Aerial Spray: residential areas (any pesticide) Expanded buffers for amine and acid formulations of 2,4-D
Buffer next to Agriculture Lands	0' Aerial Spray	100' Aerial Spray	2,640' (0.5 mile) Aerial Spray High volatile ester formulations of 2,4-D may not be aerially applied within 5 miles of susceptible crops.
Posting Spray Site	No posting	Must post five days in advance and 15 days after spraying	No posting

Protection Area	Oregon State Forest Practices Act	Washington State Forest Practices Act	Idaho Forest Practices Act
Process for Public Review and Environmental Analysis	No	Yes Utilizes an environmental analysis (SEPA)[15] that is tiered the National Environmental Policy Act (NEPA)	No
Agency Review Period	No Review	Three Weeks	No Review
Application Records Available to the Public	No	Yes, under circumstances, e.g. health and property loss	No
Years Records are Kept	Three Years	Seven Years	Three Years

[15] The State Environmental Policy Act (SEPA) is the process for public review of your proposed operation. It requires that projects be evaluated for their impacts to the environment. An environmental checklist is required for property that was platted, for conversions, and for operations that may have potentially significant impacts on the environment.

Triangle Lake School Drinking Water Case Study

The Triangle Lake School drinking water was tested by the U.S. Department of Agriculture for pesticides in 2012. Imazapyr, a common forestry herbicide, was detected. This case study illustrates the differences in protecting drinking water and ground water between Washington and Oregon. In Washington, drinking water is protected by a 100- to 200- foot spray buffer (for both aerial and ground sprays); whereas in Oregon the buffer is substantially smaller, 10 to 60 feet (Table 12). If the drinking water is from a ground water source, Washington provides additional protections in the form of pesticide restrictions and an environmental impact analysis. Oregon does not address ground water protection.

In 2008 Weyerhaeuser Company clearcut a unit on the hill above the Triangle Lake School (grades K-12). The Blachley School District owned some acreage directly behind the school. However, fear of blowdown due to the opening from the Weyerhaueser clearcut upslope convinced the school district to follow Weyerhauser's recommendation to remove all trees on the hillside, including those on school district land (Figure 22 and Figure 23).

Weyerhaeuser ground sprayed imazapyr and triclopyr on the 49-acre unit directly uphill of the school on 8/26/2009 and 9/1/2009 (Oregon Department of Forestry application record 2009-781-50456, unit 7). The Blachly School District ground sprayed imazapyr on one acre of their land above the school on 12/31/2010 (Oregon Department of Forestry application Record 2010-781-00877, unit 1).

In Oregon this spray required only a ten-foot buffer. Washington regulations require larger buffers to help increase filtration, dilution and time of travel to drinking water sources. Under the Washington State Forest Practices Act, a 150-foot buffer (for a ground spray) would have been required for the Triangle Lake School drinking water source.

In spring 2012, the Oregon Health Authority, as part of a national study of pesticides in school drinking water conducted by the U.S. Department of Agriculture, tested Triangle Lake School's well water for pesticides. Imazapyr, sprayed over fifteen months earlier on the hillside above the school, tested positive in these samples (Oregon Health Authority, 2012).

Figure 22. 2008 clearcut near Triangle Lake School classrooms and drinking water source. Well and holding tanks are in center of photo.

Figure 23. 2008 Slash burning of clearcut during school hours

Figure 24 displays the location of the school's well and the school land boundary. Figure 24 also displays how a hypothetical 150-foot buffer would have been applied at this vulnerable site.

A school serving children ages six to eighteen should be considered a vulnerable site. Oregon should require stringent protections to prevent chemicals entering ground water used for drinking water.

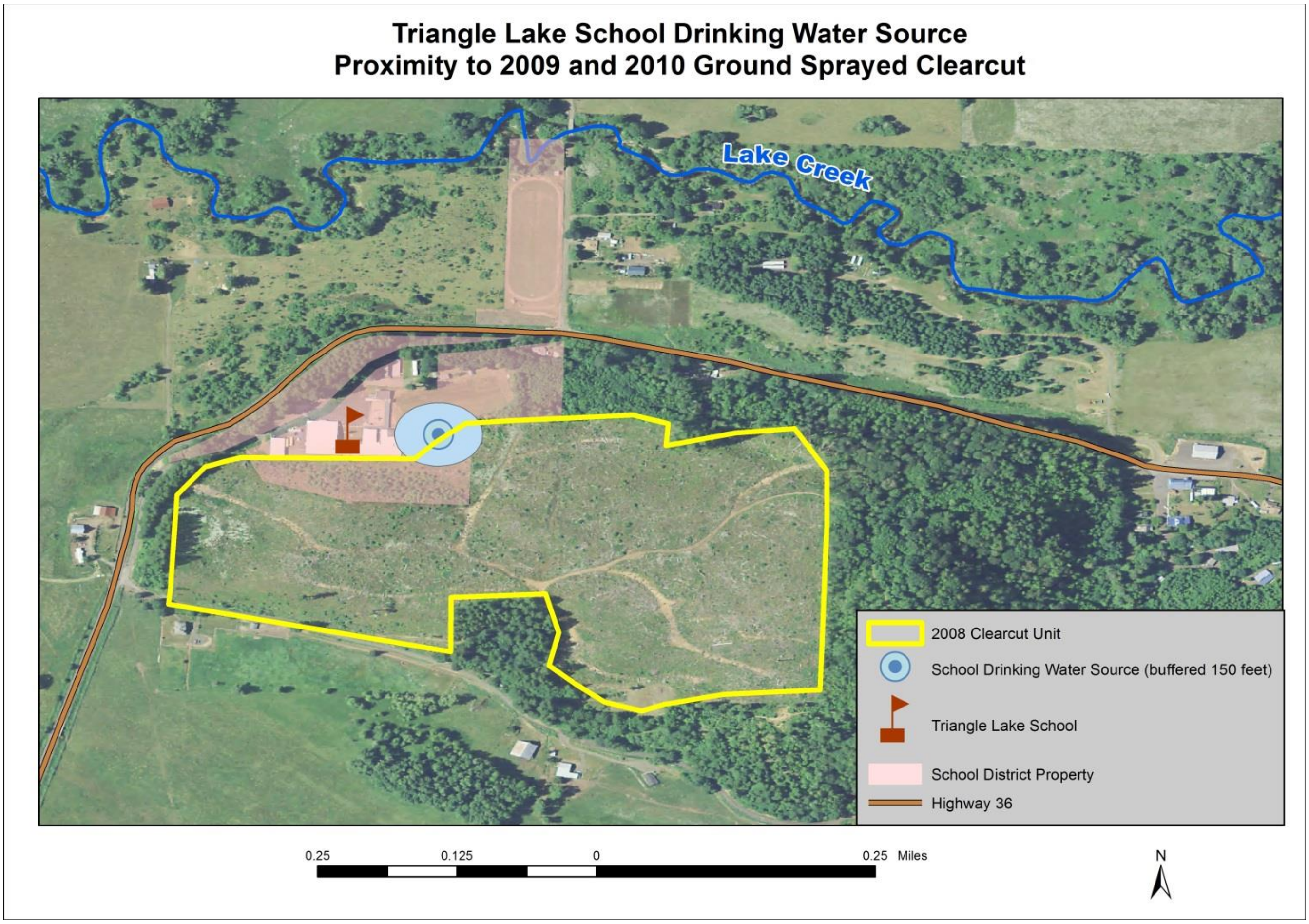

Figure 24. Proximity of Pesticide Spray to School Drinking Water Source

Summary of Washington-Idaho-Oregon Forest Practices Acts

The Oregon Forest Practices Act lacks best management practices to protect environment and human health in each category listed in Table 12. Notably, stream protections are weaker, buffers protecting residential areas, schools and agriculture sites are absent and drinking water protections are not addressed.

A list of key difference where the Oregon Forest Practices Act is deficient when compared to Washington’s regulatory approach includes:

- Protection for all surface waters
- Protection of ground water and drinking water
- Protection for residential and agricultural areas
- Regulatory accountability
- Public access to pesticide spray documents
- Public comment opportunities without financial penalties

Idaho has greater protection for all surface waters and drinking water sources. The Idaho State Forest Practices Act requires a 100-foot buffer when aerial spraying adjacent to all streams with flowing water, whether fish are present or not. Oregon has no buffer for non-fish streams, regardless if surface water is present or not.

Idaho protects residential areas with one-half mile no-spray buffer for aerial applications. Oregon removed no-spray buffers around residential homes during a rule review in the mid-1990s.

Comparison to Federal Land Management

In the 1980s, federal land managed by the U.S. Forest Service and Bureau of Land Management (BLM) stopped the routine use of herbicide spraying after clearcutting. The policy prohibits aerial spray and the use of herbicides for industrial timber management enhancement. The Atlantic (Lobet, 2012) summarizes the situation well:

> *The U.S. Forest Service, the other major timber grower in Oregon, gave up nearly all herbicide use in the Northwest back in the 1980s…."I find it somewhat ironic," said Jim Furnish, who managed the Siuslaw National Forest in Oregon in the 1990s, "that it has been -- what? -- 20 years and counting since this practice stopped on national forest lands. But it continues on industry land…. It was more costly, more labor intensive. But forestry in*

> *Oregon is profitable under many different scenarios,” said Furnish, who later became deputy chief of the Forest Service.*

In 2012 the BLM undertook an environmental analysis to gather data for decision making about the use of pesticides for land management. The Record of Decision concluded that aerial spray would be prohibited in Western Oregon (Bureau of Land Management, 2011).

Federal agencies that manage resource lands within the study area have concluded that aerial herbicide spray is not an environmentally sound practice and is not necessary for industrial harvesting of timber.

Conclusion

The Oregon Forest Practices Act (FPA) and associated state regulations are not adequately protecting Oregon’s natural resources. Furthermore the FPA fails to protect human health by excluding this legal and ethical responsibility from its regulations. The FPA was enacted over forty years ago with subsequent minor updates in the 1990s. Additional rule changes led to reductions to human health protection and agency oversight and created barriers to public input. The outcome is an outdated, ineffectual law that lacks protections for homes, fish streams, drinking water and food production sites. State agencies have shown little accountability for developing ecologically sound guidelines. This has resulted in complaints of pesticide poisoning in rural communities and lawsuits alleging the state’s failure to meet water quality standards.

Within the State of Oregon, residents living proximal to industrial forestlands have no way of knowing when aerial sprays will occur or what chemicals will be used. Herbicide spray records are held privately by the spray operators, and are not available to the public, medical professionals or to other state agencies. Until the 2009 to 2011 spray application records analyzed in this report became available through the Oregon Health Authority *Public Health Assessment Highway 36 Corridor Exposure Investigation*, it was unknown exactly what chemicals, and amounts of chemicals, were being sprayed. The spray application records also revealed chemicals are commonly combined. Research shows that when chemicals are combined, they can react with each other resulting in a larger synergistic effect. The chemical combinations sprayed in this study area have not been studied, therefore the entirety of effects are unknown.

The data shows pounds of pesticides, pesticides per acre and amount of acres sprayed increased exponentially over a three year window. Cumulative effects of multiple applications within watersheds are not being analyzed. For example, in 2011 rural residents were potentially exposed to 23 individual aerial sprays within a six week period with a cocktail of chemicals.

The Oregon Board of Forestry, is charged with the responsibility to "supervise all matters of forest policy and management under the jurisdiction of the state …" (ORS 526.016). The Forest Practices Act gives the Board exclusive authority to adopt and enforce rules governing forest practices (Board of Forestry, 2011).

Biennially, the Board solicits public input to shape their annual work plan. In various internal documents, the Board of Forestry confirmed that public concern over health, pesticide drift and contamination emerges as a top public issue (Oregon Board of Forestry, 2009). Nonetheless, the Board's work plans adopted in 2011 and 2013 do not specifically identify human or public health as key objectives. This is contradictory because the Board itself "has recognized that its mandate to protect water and air quality does indirectly relate to protection of human health (Oregon Department of Forestry, 2011)." The contradiction is likely due to the absence of a statutory requirement to adopt rules protecting public health in the Forest Practices Act (except in the case of landslides and public safety).

Impacts to public health and the environment need to be avoided, including the federally listed threatened coastal Coho salmon. In order to provide these protections, Oregon needs to update their rules, just as Idaho and Washington have, so that the federal regulations are met or exceeded. Oregon Forest Practices Act emphasizes voluntary and non-regulatory methods of forest management, which is inadequate to the necessity of ecosystem protections.

According to John Blackwell, the 2011 Chair of the Board of Forestry (Board of Forestry, 2011):

> *"… Oregonians' own indicators of sustainable forest management provide evidence Oregon's forests, in total, are <u>not</u> currently being managed sustainably."* (original emphasis, page 6)

Unlike Washington and Idaho, the Oregon Forest Practices Act does not protect all surface waters. Washington and Idaho have policies that reflect an understanding that surface waters, regardless if fish are present, have direct effects on downstream fish streams.

Furthermore, Oregon rules are not aligned with federal regulations for protecting water quality. Some Oregon rules lack restrictions to protect streams or control certain chemicals by conflicting with EPA label restrictions and the Clean Water Act. The inconsistencies may contribute to water quality impairment.

The Oregon Forest Practices Act is not protecting human health. Aerial spraying of herbicides has direct and indirect effect on residents. According to the Oregon Health Authority, drift and re-volatilization is known to occur at least two to four miles away from an aerial spray (Oregon Health Authority, 2013). Runoff into streams can indirectly affect ground water which ultimately can poison drinking water.

These impacts are not limited to the study area. Aerial spraying of herbicides occurs throughout Oregon. The effects from repeated aerial spraying of chemicals in rural western Oregon are identified by many communities as causing harm to the residents living in the area.[16] The complaints are unique yet share many commonalities related to types of illness experienced, impacts to children, operator negligence, lack of responsiveness from forest property owners, lack of agency oversight, concerns over drinking water quality and harm to domestic animals. , The complaints come from too many different communities to ignore.

Protecting our residents and environment needs to be a priority for the state. The following list of recommendations provides the road map to ensure a sustainable forest as well as respect and livability for all Oregonians.

List of Recommendations

Policy Recommendations

1. The State should make the Oregon Forest Practices Act equal to or more effective than the Washington Forest Practices Act.
2. Make all forest operations, including chemical application documents available through a publicly accessible website similar to Washington's Forest Practices Application Review System (FPARS).
3. Provide the Oregon Department of Forestry, in consultation with the Oregon Department of Environmental Quality, the authority to review, comment, and require modifications of forest vegetation management written plans based

[16] The state's Pesticide Analytical Response Center has received numerous complaints from communities from the southern tip of Oregon's coast in Curry County (as recently as 2013 from Gold Beach) to the northwestern county of Tillamook (as recently as 2013 from Rockaway Beach), and communities in between (Roseburg, Cottage Grove, Cedar Valley, Selma, Florence, Blachly, Stayton, Alpine, Deadwood, Lorane, Creswell, and others).

on an environmental and human health assessment and proof of compliance with state and federal laws. Require written plans to be made available for public review and comment.

4. Embed a human rights perspective in environmental policy to ensure the public's right to be protected on their private property and on public property, and their right to know and to comment upon chemical applications in the vicinity of homes, schools, public facilities and drinking water.

Forest Practices Recommendations

1. Provide for state agency evaluation of pesticide applications, make public comment part of the evaluation, and issue a permit based on an environmental assessment and proof of compliance with state and federal laws.
2. Comply with ORS 629-035-0030 subsection 3(B), to protect all surface waters. Acknowledging and acting to protect the hydrological connection between headwaters and downstream fish-bearing streams will enable compliance with the requirement to ensure a "high probability of maintaining and restoring properly functioning aquatic habitats for salmonids, and other native fish and aquatic life, and protecting, maintaining, and enhancing native wildlife habitats (State of Oregon, 2013c)." A minimal step would be to adopt water quality protection standards consistent with neighboring state Washington.
3. Establish stringent ground water and drinking water protection areas that take into account the hydrologic connection between surface water and ground water.
4. Require state agency staff to monitor forestry operations where surface or ground water protection is part of the environmental assessment. Monitoring includes in-stream monitoring for pesticides and their breakdown products, as well as on-site visual inspection of forestry operation activities.
5. Ban chemicals that tend to travel in water or soil, such as atrazine and hexazinone.
6. Educate land owners and encourage the use of mechanical methods to remove unwanted vegetation.
7. Create a public access website that, without charge to the public, provides: 1) a timely notification of pending pesticide sprays (unit location, chemicals, date, operator); 2) full record of agency's environmental assessment and proof of compliance with state and federal laws; 3) pesticide spray record no

more than 7 working days after the forestry operation; and 4) retain spray application records for at least 7 years.

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Appendix A

Methods and Data Sources

Beyond Toxics purchased Geographic Information System (GIS) software from the private company ESRI consisting of ArcGIS, versions 10.0 and 10.1. This software was used to develop the maps and generate the information tables found in this report.

Information regarding herbicide applications for private and state forestry operations was taken directly from spray application records provided by the Oregon Department of Forestry. A total of 242 aerial and ground spray records were obtained and analyzed for this report. These records generally provided the township, range and section of the properties on which herbicide products were applied, as well as the type of application (aerial, pressurized ground spray, various hand application methods), the date and time of application, the amount of each herbicide applied and weather conditions at the time of application. Some but not all of the records contained the size of the area that had been treated with herbicides, in acres. The records contained information from 2009 through 2011.

Aerial photos of the general area, taken in 2009 and 2011, were obtained from ESRI, and were produced by the National Agricultural Imagery Program (NAIP) of the U.S. Department of Agriculture. The aerial photos were used in two ways: to identify clearcut areas where herbicides had been applied, and as the background for individual maps that were prepared as part of the project.

Individual townships, ranges and sections are part of the Public Lands Survey System (PLSS); and a Geographic Information System (GIS) layer of the PLSS was obtained from the Oregon Geospatial Data Library (Oregon State, 2011). In most cases, the herbicide application record contained a map showing a clearcut area that was to receive the herbicide application, and once the township, range and section were located using the PLSS layer, the aerial photo revealed a clearcut similar in shape and size to that shown in the map on the application record. This area was then digitized by tracing around the edges of the clearcut area. In several instances where the area shown in the record consisted of more than one non-contiguous area, two or more polygons were digitized.

The Oregon Health Authority requested records covering specific townships and ranges as follows:

Township:	**Range:**
15 South	6 West
15 South	7 West
16 South	6 West
16 South	7 West
16 South	8 West
17 South	7 West
17 South	8 West
17 South	9 West

These areas were located on the map using the PLSS GIS layer. They are designated on maps in the report as the study area. The study area consists of a total of eight Township/Range combinations, each consisting of 36 sections, with each of those sections consisting of 640 acres, or a total of 184,320 acres.

The watersheds, streams, lakes and roads shown on the map in this report were developed from GIS layers provided by the Oregon Geospatial Data Library (2011). That was also the source for the GIS layer developed by the Oregon Department of Fish and Wildlife showing the extent of habitat for anadromous salmonid fishes. The classification of salmonid habitat in terms of core cold water areas and times of salmonid spawning were obtained from OAR 340-041-0028 (Oregon DEQ, 2003a) and (Oregon DEQ, 2003b).

The 2011 aerial photo showed the most densely populated region of the study area to be primarily the area close to Highway 36 that runs west of Triangle Lake through the Lake Creek Watershed of the Siuslaw Basin. The 2011 aerial photo was used to develop a polygon representing the highest population density for use in this report. By concentrating on residential density, some individual homesteads may not be shown in these shaded polygons.

Herbicide application records were used to develop a spreadsheet that contained the application record number, the name of the landowner, the name of the herbicide applicator, the landowner's unit name, the size of the area sprayed, and the names of the herbicides applied to the unit. Later, information regarding weather data and the quantity of herbicides used was added to the spreadsheet.

The spreadsheet was then entered into the GIS system, and the area that had been sprayed was located and digitized as explained earlier. As a check on accuracy, the acreage of each unit was calculated using a tool in the GIS system, and compared to the acreage in the herbicide application record.

After all the aerial applications had been digitized, the GIS system was used to develop maps showing the extent of pesticide applications by private forest operators within the study area. Following development of the maps of aerial application, a similar spreadsheet was developed for the pesticide applications made by ground-based methods. That spreadsheet was also entered into GIS and maps were developed showing ground-based pesticide applications. When maps were not included in the ground spray records, and it was difficult to identify the exact location of the spray operation, we created circular shapes to indicate that a spray occurred in that Township, Range and Section. The size of the circle is relative to the acreage reported on the application record. We were unable to map the records with missing acreage information, unless we could find the application notice in the Oregon Department of Forestry's FACTS database (Oregon Department of Forestry, FACTS website), in which case we used the acreage in the notice.

Additionally, after all pesticide applications had been digitized and habitat for anadromous salmonids identified, a buffer tool in the GIS system was used to calculate the number of miles of anadromous salmonid habitat located within 300 feet of a herbicide application. The results are discussed in the report.

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Appendix B
Example of a Pesticide Spray Notification

~~Unit~~ Information - Notification: 201377100646
Unit 1 of 1 Start: 08/05/13 End: 10/15/13
Status: Open
Stewardship Forester: Tim Meehan

Priorities: **Fire: Low** **FPA: Low**

Site Conditions Waters: Lake or stream Within 100 feet.
Soils: No mass soil movement.
Slope: Greater than 65%.
SF Phone Number: (541)726-3588

			NE				NW				SW				SE						
Twp	**Rge**	**Sec**	**NE**	**NW**	**SW**	**SE**	**NE**	**NW**	**SW**	**SE**	**NE**	**NW**	**SW**	**SE**	**NE**	**NW**	**SW**	**SE**	**Government Lot Number**	**Tax Lot No.**	**Reg Use**
16S	02W	12	☐	☑	☑	☐	☑	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐			EL-1

Activity	Method	Acres	Feet	MBF	Comment
4a - Herbicide Application	Aerial operation / applications	93.00	0	0	Brand: Milestone VM Plus, Capstone, Opensight, Rodeo, Accord XRT II, Polaris SP, Polaris AC, Metcel VMF, Escort, Sulfomet Extra, Oust Extra, Sulfomet, Oust XP, Forestry Garlon XRT, Garlon 3A, Garlon 4 Ultra; Common: Aminopyralid, Aminopyralid, Aminopyralid, Glyphosate, Glyphosate, Imazapyr, Imazapyr, Metsulfuron methyl, Metsulfuron methyl, Metsulfuron methyl, Metsulfuron methyl, Metsulfuron methyl, Sulfometuron methyl, Sulfometuron methyl, Triclopyr, Triclopyr, Triclopyr; Additives: Dyne-Amic, Foam Buster, Hasten, Induce, LI 700, MSO, No Foam, Syl-Tac, Sylgard 309; Comments: +Sulfometuron Methyl, +Sulfometuron Methyl, Complete, Crosshair; Strike Zone-Drift Control Agent, Epoleon, Odor Mask-Odor Neutralizer, Fire Zone-Vegetable Oil, Insist 90-Silicon Surfactant, Kinetic-Silicon Surfactant, Metsulfuron Methyl, Mineral Oil, MSM 60DF, Silicon Defoamer, Silicon Defoamer, Silicon Surfactant, Silicon Surfactant, Silicon Surfactant, Triclopyr, Triclopyr, Vegetable Oil, Vegetable Oil, Vegetabl

Resource Name	Resource Description
Mohawk River Trib	Mohawk River Trib: Small Non-Fish Stream(s)
	No Threatened or Endangered Species Found.
	No Special Concerns Found.

Appendix C
Annotated Bibliography of Human Health Effects from Atrazine, 2,4-D and Synergistic Exposures

The literature on forestry pesticides is extensive and cannot be reviewed in this report. Numerous studies have been conducted that look at the health risk of herbicides. Two particular herbicides, atrazine and 2,4-D were applied at increasing amounts during the three-year study window. These chemicals were sprayed during the spring 2011 when residents provided urine samples to researchers. Atrazine and 2,4-D were detected in these urine samples. Refer to the *Human Health and Chemical Forestry Practices* Section in the report. To help illustrate the potential risk of human exposure to these herbicides, a limited selection of studies on atrazine and 2,4-D are listed below.

Atrazine

Fetal Growth Restriction and small head circumference. (Chevrier, et al., 2011)

The study found that the presence versus absence of quantifiable levels of atrazine or a specific atrazine metabolite was associated with fetal growth restriction [odds ratio (OR) = 1.5; 95% confidence interval (CI), 1.0-2.2] and small head circumference for sex and gestational age (OR = 1.7; 95% CI, 1.0-2.7). Head circumference was inversely associated with the presence of quantifiable urinary metolachlor. This study is the first to assess associations of birth outcomes with multiple urinary biomarkers of exposure to triazine and chloroacetanilide herbicides. Evidence of associations with adverse birth outcomes raises particular concerns for countries where atrazine is still in use.

Case-control study of maternal residential atrazine exposure and male genital malformations. (Agopian A.J., 2013)

Exposure to endocrine disrupting chemicals has been associated with risk for male genital malformations. However, residential prenatal exposure to atrazine, an endocrine disrupting pesticide, has not been evaluated. We obtained data from the Texas Birth Defects Registry for 16,433 cases with isolated male genital malformations and randomly selected, population-based controls delivered during 1999-2008. County-level estimates of atrazine exposure from the United States Geological Survey were linked to all subjects. We evaluated the relationship between estimated maternal residential atrazine exposure and risk for male genital malformations in offspring: hypospadias, cryptorchidism, and small penis. We observed modest, but consistent, associations between medium-low and/or medium levels of estimated periconceptional maternal residential atrazine exposure and every male genital malformation category evaluated (e.g., adjusted odds ratio for medium compared to low atrazine levels and all male genital malformations: 1.2, 95% confidence interval: 1.1-1.3). Previous literature from animal and epidemiological studies supports our findings. Our results provide further evidence of a suspected teratogenic role of atrazine.

Triazine herbicides and their chlorometabolites alter steroidogenesis in BLTK1 murine leydig cells. (Forgacs A.L., 2013)

The triazine herbicides, atrazine (ATR), simazine (SIM), propazine (PRO), terbuthylazine (TBA), and their chlorinated metabolites have been implicated in the etiology of testicular dysgenesis by altering steroidogenesis. To further investigate their effects on testosterone biosynthesis, BLTK1 cells were used to evaluate steroid hormone levels and genome-wide gene expression. Whole-genome microarrays identified 797 differentially regulated genes elicited by 300 µM ATR, occurring primarily at later time points (> 12h) with overrepresented functions associated with steroidogenesis and cholesterol metabolism. These results indicate that changes in progesterone (P) and basal testosterone (T) levels can be partially attributed to triazine-elicited alterations in steroidogenic gene expression.

Maternal residential atrazine exposure and risk for choanal atresia and stenosis in offspring. (Agopian, 2013)

To assess the relationship between estimated residential maternal exposure to atrazine during pregnancy and the risk for choanal atresia or stenosis in offspring. Compared with offspring of mothers with low levels of estimated residential atrazine exposure, those with high levels had nearly a 2-fold increase in risk for choanal atresia or stenosis (aOR, 1.79; 95% CI, 1.17-2.74). A significant linear trend was also observed with increasing levels of atrazine exposure (adjusted P = .002). A link between maternal exposure to endocrine disruptors, such as atrazine, and the risk of choanal atresia is plausible based on previous findings. Our results lend further support to this hypothesis.

Involvement of ERK1/2 signaling pathway in atrazine action on FSH-stimulated LHR and CYP19A1 expression in rat granulosa cells. (Fa S., 2013)

Worldwide used herbicide atrazine is linked to reproductive dysfunction in females. In this study, we investigated the effects and the mechanism of atrazine action in the ovary using a primary culture of immature granulosa cells. 48h after atrazine exposure the FSH-stimulated LHR and CYP19A1 mRNA expression and estradiol synthesis were decreased, with LHR mRNA being more sensitive to atrazine than CYP19A1 mRNA. Inadequate acquisition of LHR in the FSH-stimulated and atrazine-exposed granulosa cells renders human chorionic gonadotropin (hCG) ineffective, suggesting anti-ovulatory effect of atrazine. The results from this study reveal that atrazine does not affect but requires ERK1/2 phosphorylation to cause decrease in the FSH-induced LHR and CYP19A1 mRNA levels and estradiol production in immature granulosa cells, thus compromising ovulation and female fertility.

Atrazine-Induced Aromatase Expression Is SF-1 Dependent: Implications for Endocrine Disruption in Wildlife and Reproductive Cancers in Humans. (WuQiang Fan, 2007)

The current findings are consistent with atrazine's endocrine-disrupting effects in fish, amphibians, and reptiles; the induction of mammary and prostate cancer in laboratory rodents; and correlations between atrazine and similar reproductive cancers in humans. This study highlights the importance of atrazine as a risk factor in endocrine disruption in wildlife and reproductive cancers in laboratory rodents and humans.

Early-life exposure to a herbicide has enduring effects on pathogen-induced mortality. (Rohr JR, 2013)

Exposure to stressors at formative stages in the development of wildlife and humans can have enduring effects on health. Understanding which, when and how stressors cause enduring health effects is crucial because these stressors might then be avoided or mitigated during formative stages to prevent lasting increases in disease susceptibility. Early-life, 6-day exposure to the herbicide atrazine increased frog mortality 46 days after atrazine exposure (post-metamorphosis), but only when frogs were challenged with a chytrid fungus implicated in global amphibian declines. Previous atrazine exposure did not affect resistance of infection. Rather, early-life exposure to atrazine altered growth and development, which resulted in exposure to chytrid at more susceptible developmental stages and sizes, and reduced tolerance of infection, elevating mortality risk at an equivalent fungal burden to frogs unexposed to atrazine. Moreover, there was no evidence of recovery from atrazine exposure. Hence, reducing early-life exposure of amphibians to atrazine could reduce lasting increases in the risk of mortality from a disease associated with worldwide amphibian declines. More generally, these findings highlight that a better understanding of how stressors cause enduring effects on disease susceptibility could facilitate disease prevention in wildlife and humans, an approach that is often more cost-effective and efficient than reactive medicine.

Effect of atrazine administration on spontaneous and evoked cerebellar activity in the rat. (Podda, 1997).

Rats acutely treated with atrazine (100 mg kg-1, BW) showed a significant decrease in spontaneous Purkinje cell firing rate. Atrazine also decreased the cerebellar potentials evoked by electrical stimulation of the ipsilateral radial nerve, affecting mostly the response to climbing fiber input. These results demonstrate that atrazine exerts a toxic action on central nervous system. The effects on the cerebellar somatosensory cortex could be responsible for motor disorders frequently observed in animals intoxicated with Atrazine.

Demasculinization and feminization of male gonads by atrazine: consistent effects across vertebrate classes. (Hayes T. e., 2011)

Atrazine is an endocrine disruptor that, among other effects, alters male reproductive tissues when animals are exposed during development. Here, we apply the nine so-called "Hill criteria" (Strength, Consistency, Specificity, Temporality, Biological Gradient, Plausibility, Coherence, Experiment, and Analogy) for establishing cause-effect relationships to examine the evidence for atrazine as an endocrine disruptor that demasculinizes and feminizes the gonads of male vertebrates. Atrazine demasculinizes male gonads producing testicular lesions associated with reduced germ cell numbers in teleost fish, amphibians, reptiles, and mammals, and induces partial and/or complete feminization in fish, amphibians, and reptiles. These effects are strong (statistically significant), consistent across vertebrate classes, and specific. Reductions in androgen levels and the induction of estrogen synthesis - demonstrated in fish, amphibians, reptiles, and mammals - represent plausible and coherent mechanisms that explain these effects. Given that the effects on the male gonads described in all of these experimental studies occurred only after atrazine exposure, temporality is also met here. Thus the case for atrazine as an endocrine disruptor that demasculinizes and feminizes male vertebrates meets all nine of the "Hill criteria".

Hormones and endocrine-disrupting chemicals: low-dose effects and nonmonotonic dose responses (Vandenberg L.N., 2012).

For decades, studies of endocrine-disrupting chemicals (EDCs) have challenged traditional concepts in toxicology, in particular the dogma of "the dose makes the poison," because EDCs can have effects at low doses that are not predicted by effects at higher doses. Here, we review two major concepts in EDC studies: low dose and nonmonotonicity. Low-dose effects were defined by the National Toxicology Program as those that occur in the range of human exposures or effects observed at doses below those used for traditional toxicological studies. We review the mechanistic data for low-dose effects and use a weight-of-evidence approach to analyze five examples from the EDC literature. Additionally, we explore nonmonotonic dose-response curves, defined as a nonlinear relationship between dose and effect where the slope of the curve changes sign somewhere within the range of doses examined. We provide a detailed discussion of the mechanisms responsible for generating these phenomena, plus hundreds of examples from the cell culture, animal, and epidemiology literature. We illustrate that nonmonotonic responses and low-dose effects are remarkably common in studies of natural hormones and EDCs. Whether low doses of EDCs influence certain human disorders is no longer conjecture, because epidemiological studies show that environmental exposures to EDCs are associated with human diseases and disabilities. We conclude that when nonmonotonic dose-response curves occur, the effects of low doses cannot be predicted by the effects observed at high doses. Thus, fundamental changes in chemical testing and safety determination are needed to protect human health.

Estimation of placental and lactational transfer and tissue distribution of atrazine and its main metabolites in rodent dams, fetuses, and neonates with physiologically based pharmacokinetic modeling. (Lin, 2013)

Atrazine (ATR) is a widely used chlorotriazine herbicide, a ubiquitous environmental contaminant, and a potential developmental toxicant. To quantitatively evaluate placental/lactational transfer and fetal/neonatal tissue dosimetry of ATR and its major metabolites, physiologically based pharmacokinetic models were developed for rat dams, fetuses and neonates. Model simulations corresponded well to the majority of available experimental data and suggest that: (1) the fetus is exposed to both ATR and its major metabolite didealkylatrazine (DACT) at levels similar to maternal plasma levels, (2) the neonate is exposed mostly to DACT at levels two-thirds lower than maternal plasma or fetal levels, while lactational exposure to ATR is minimal, and (3) gestational carryover of DACT greatly affects its neonatal dosimetry up until mid-lactation.

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2,4 Dichlorophenoxyacetic acid (2,4-D)

Phenoxy herbicides and fibrates potently inhibit the human chemosensory receptor subunit T1R3 (Emeline L. Maillet, 2009)

Several of the phenoxy-herbicides tested here are among the most widely used, e.g. 2,4D. They have low soil sorption, high leachability, and are prone to enter the human food chain. Long-term biological effects of these compounds in humans are largely unknown and based on our studies their actions on T1R3-containing receptors would not have manifested in rodent models. We think it prudent to evaluate effects of acute and chronic exposure to these compounds specifically on human metabolism and development.

2,4 Dichlorophenoxyacetic acid residues in semen of Ontario farmers. (Arbuckle TE, 1999)

Although paternal exposures to environmental toxicants probably play a role in adverse pregnancy outcomes, few data are available on the extent of this exposure. One semen and two 24-h urine samples were collected from 97 Ontario farmers who had recently used the phenoxy herbicides 2,4-D (2.4-dichlorophenoxyacetic acid) and/or MCPA ([4- chloro-2-methylphenoxyl acetic acid). Both samples were analyzed for 2,4-D using an immunoassay-based technique. Approximately 50% of the semen samples had detectable levels of 2, 4-D (> or =5.0 pph (ng/mL)). Semen levels of 2.4-D were correlated more closely with the second of the two urine samples. Although several studies have measured 2.4-D in the urine of applicators, this study is the first to attempt to measure 2,4-D levels in semen. As these pesticides can be excreted in the semen, they could be toxic to sperm cells and be transported to the woman and developing embryo/fetus. Further research is needed to understand how pesticide handling practices can affect semen pesticide residues and the relationship between the levels observed and reproductive health.

Pesticide Appliers, Biocides, and Birth Defects in Rural Minnesota. (Garry, 1996)

This study found that the rate of birth defects is [significantly] increased in: 1) offspring born to licensed private appliers; 2) offspring born to the general population residing in high-use chlorophenoxy herbicide/fungicide regions; and 3) infants conceived in spring. The increase in birth defects was significantly associated with atrazine use only when use was >100,000 pounds in a given county. The increased incidence of birth defects was also associated with 2,4-D use.

Case-control study of canine malignant lymphoma: positive association with dog owner's use of 2,4-dichlorophenoxyacetic acid herbicides. (Hayes H.M., 1194)

Case-control study of companion dogs examined the risk of developing canine malignant lymphoma associated with the use of chemicals in and about the home. Owners in households with dogs that developed malignant lymphoma applied 2,4-dichlorophenoxyacetic acid (2,4-D) herbicides to their lawn and/or employed commercial lawn care companies to treat their yard significantly more frequently than control owners (odds ratio = 1.3). In addition, the risk of canine malignant lymphoma rose to a twofold excess with four or more yearly owner applications of 2,4-D. The findings in this study are consistent with occupational studies in humans, which have reported modest associations between agricultural exposure to 2,4-D and increased risk of non-Hodgkin's lymphoma, the histology and epidemiology of which are similar to those of canine malignant lymphoma. The present study suggests that human health implications of 2,4-D exposure in the home environment should receive further investigation.

2,4-D Human Health and Ecological Risk Assessment, Final Report–US Forest Service (2006)

Based on recent studies published in the open literature, 2,4-D is toxic to the immune system and developing immune system, especially when used in combination with other herbicides. The mechanism of action of 2,4-D toxicity is cell membrane disruption and cellular metabolic processes. The molecular basis for 2,4-D toxicity to human lymphocytes and nerve tissue is likely the induction of programmed cellular death known as apoptosis.

Occupation and Risk of ParkinsonismA Multicenter Case-Control Study (Tanner, 2009)

Risk of parkinsonism increased with pesticide use (odds ratio, 1.90; 95% confidence interval, 1.12-3.21), use of any of 8 pesticides mechanistically associated with experimental parkinsonism (2.20; 1.02-4.75), and use of 2,4-dichlorophenoxyacetic acid (2.59; 1.03-6.48).

Soft Tissue Sarcoma and Non-Hodgkin's Lymphoma in Workers Exposed to Phenoxy Herbicides… (Kogeviras, M., et al. Epidemiology 1995, 196-402)

Workers exposed to 2,4-D, a phenoxy herbicide, and its contaminants were more at risk for developing soft tissue sarcomas.

Endocrine Disruptors and Synergistic Exposures through Chemical Mixtures

Hormones and endocrine-disrupting chemicals: low-dose effects and nonmonotonic dose responses. (Vandenberg L.N., 2012)

For decades, studies of endocrine-disrupting chemicals (EDCs) have challenged traditional concepts in toxicology, in particular the dogma of "the dose makes the poison," because EDCs can have effects at low doses that are not predicted by effects at higher doses. Here, we review two major concepts in EDC studies: low dose and nonmonotonicity. Low-dose effects were defined by the National Toxicology Program as those that occur in the range of human exposures or effects observed at doses below those used for traditional toxicological studies. We review the mechanistic data for low-dose effects and use a weight-of-evidence approach to analyze five examples from the EDC literature. Additionally, we explore nonmonotonic dose-response curves, defined as a nonlinear relationship between dose and effect where the slope of the curve changes sign somewhere within the range of doses examined. We provide a detailed discussion of the mechanisms responsible for generating these phenomena. We illustrate that nonmonotonic responses and low-dose effects are remarkably common in studies of natural hormones and EDCs. Whether low doses of EDCs influence certain human disorders is no longer conjecture, because epidemiological studies show that environmental exposures to EDCs are associated with human diseases and disabilities. We conclude that when nonmonotonic dose-response curves occur, the effects of low doses cannot be predicted by the effects observed at high doses. Thus, fundamental changes in chemical testing and safety determination are needed to protect human health.

Ake Bergman, Jerrold J. Heindel, Susan Jobling, Karen A. Kidd and R. Thomas Zoeller. "**State of the Science of Endocrine Disrupting Chemicals – 2012,**" **United Nations Environment Programme and the World Health Organization, 2013.**

A number of exogenous chemicals have now been shown to influence epigenetic mechanisms and to produce effects in several generations of animals. We have a great deal to learn about this issue, but it is plausible that chemical exposures during pregnancy will affect the health of several subsequent generations of people and wildlife that are not themselves exposed (p. 15). Several studies have shown that circulating estradiol concentrations in rodents can be decreased by exposure to several pesticides, including heptachlor, lindane, atrazine, simazine or hexachlorobenzene (p. 39).

Fetal and Neonatal Endocrine Disruptors (Unuvar, 2012 4(2) 51-60)

Epidemiological and toxicological studies that have been performed over the years and have provided scientific data for the protection of human health and wildlife have shown that nature as a whole is under risk due to these chemical [endocrine disruptors, including 2,4-D). These studies also provide evidence to inform local authorities about this threat and about preventative measures to be taken on the issue of endocrine disruptors, particularly with regard to pregnant women and children. Further animal and human studies are also needed to investigate the effects of intrauterine endocrine disruptor exposure on adult health. (See extensive bibliography included in article.)

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Appendix D

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A Human Rights Assessment of Aerial Herbicide Applications Near and Adjacent To Triangle Lake, Oregon

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Matter of Concern: Aerial herbicide applications over forested areas near and adjacent to Triangle Lake, Oregon

Date: July 18, 2011

Copies: John Kitzhaber, Governor John Kroger, Oregon State Attorney General Gail Shibley, Admin, Environmental Public Health Faye Stewart, Chair, Lane County Board of Commissioners Senator Joanne Verger Representative Jean Cowan Day Owen, Pitchfork Rebellion, Triangle Lake, OR Jae Douglas, Oregon Health Authority Richard Kauffman, Senior Regional Representative, ATSDR Scott Downey, Environmental Protection Agency, Region Ten

Contents:

Executive summary

Residents of Triangle Lake have been concerned about exposure to herbicides applied aerially to forestlands near their homes, and about the health impacts their families have experienced. Recent laboratory findings have been interpreted as lending credibility to their concerns.

Urine samples of thirty-four residents, including children, taken after Weyerhaeuser’s April 8 and April 19 aerial sprays, were provided to laboratories at Emory University and tested for the presence of atrazine and 2,4-D. All thirty-four urine samples tested positive for both herbicides. Two examples: one adult male’s urine showed a 129% increase in urine atrazine after the aerial applications and a 31% increase in urine 2,4-D, and an adult female resident’s urine showed a 163% increase in urine atrazine, and a 54% increase in urine 2,4-D after the aerial applications, both compared to baseline levels taken some months earlier.

Viewed in light of human rights standards, this may raise liability concerns for agencies.

Human Rights norms of concern

This report details twenty-three human rights norms of concern, including:

- The right to security of person and bodily integrity. This is one of the most basic of rights and is articulated in many human rights treaties, including the instruments that make up the International Bill of Human Rights
- The family’s right to protection – also articulated in the instruments composing the International Bill of Human Rights.
- The right of motherhood and childhood to special care and protections
- The right of the child to the highest standard of health – both of these articulated in the same instruments as well as in the 1990 *Convention on the Rights of the Child*.

In addition, the *Declaration of Alma-Ata* reminds states that they are responsible for regulating agricultural, forestry, industry, manufacturing and other sectors to protect citizens’ health.

Human rights standards are justified moral claims held by all persons vis-à-vis their governments, and moral duties that governments at all levels owe their citizens.

Human rights standards are recognized as trumping other types of policy considerations such as utility, cost-benefit analysis, social policy, etc. Additionally, human rights norms represent basic moral minimums, a moral floor beneath which state and state-regulated behaviors must not sink. If civil laws represent hard legal boundaries outside of which certain behaviors are not legally permissible, human rights standards represent hard ethical boundaries that define the outer limits of morally permissible behaviors.

Governments that sign human rights treaties, as the US has done, commit themselves to promulgating these norms and to being held accountable to them.

Potential liabilities

Potential consequences of continuing to allow aerial applications in such close proximity to residences include a risk of public and perhaps media perception that BOF, ODF and ODA do not respect human rights norms, potentially resulting in diminished trust by affected communities. Institutional trust is not high in communities impacted by aerial herbicide applications, and when lost could take decades to win back.

Potential economic risks include liability insurance carriers reconsidering their coverage, conditions and premiums for pesticide applications near human populations.

Other economic risks include potentially costly legal actions brought against BOF, ODF or ODA for failure to adequately regulate aerial application of herbicides as a violation of human rights, possible legal action re the Americans with Disabilities Act, and possible multiple small claims court actions.

One goal of human rights activism, often referred to as "the mobilization of shame," involves human rights organizations using tools such as media attention, video recording of actions considered to be human rights violations and of persons responsible for them, posting those videos publically, and holding citizens' inquiries and tribunals.

Pathways to reduce liabilities

The first step to reduce liabilities would be for BOF, ODF and ODA to initiate good faith discussions with Oregon Toxics Alliance, the Pitchfork Rebellion, and other local citizen groups, and to suspend aerial applications in the area until satisfactory agreements can be reached in those discussions.

Agencies should require that timber companies rely as much as possible on non-chemical means of vegetation control.

If some use of chemical herbicides were to be used, agencies should provide examples of well designed population studies undertaken by third parties (i.e., not pesticide manufacturers or agriculture/forestry interests) that demonstrate no adverse health effects from exposure to the relevant pesticide formulation(s). Such studies may not be available, but if they are they should be provided.

Agencies should provide wide public notification at no charge and by multiple means. Notifications should include attached labels and MSDS sheets for each relevant herbicide product.

Alternative lodging, transportation and services should be provided to those who require that they and their family members not be exposed to sprays, as well as provisions for insuring that place-bound persons not be required to endure spray exposures.

Strategies should be developed for insuring that children, because of their greater biological vulnerability to environmental exposures, not suffer exposures to sprays, drift or residues.

Agencies should arrange for health effects monitoring studies to be undertaken by the Department of Health or independent third parties. Active (not passive) surveillance should monitor for a range of adverse health effects, both acute and chronic. Representatives from citizen groups should be actively involved in all phases of these studies: design, planning, implementation and monitoring.

Agencies should arrange for regular monitoring of local air and surface waters for the chemicals used in aerial applications, to be undertaken by the Department of Health, or Department of Environmental Quality or independent third parties, again with active citizen involvement in all phases.

Oversight by external observers, agreed to by BOF, ODF, ODA and citizen environmental organizations, should be arranged to monitor the implementation phase of these studies to help insure credibility and community buy-in.

APPENDIX E
Annotated Bibliography on Herbicides and Endangered Salmon and other Aquatic Species

The literature on forestry pesticides is extensive and cannot be reviewed in this report. Numerous studies have been conducted that look at the impacts of herbicides on salmon and other aquatic species, as well as soil and soil microorganisms. Below is a relatively small sample of relevant research studies that show negative effects herbicides have on the aquatic community.

Effects of Hexazinone and Atrazine on the Physiology and Endocrinology of Smell Development in Atlantic Salmon (Nieves-Puigdoller, Thrandur, & McCormick, 2007)

In a laboratory setting, exposure to atrazine was found to cause osmoregulatory disturbance, physiological stress and reduction in food intake and growth in Atlantic salmon. The report suggests that in the wild, other stressors, such as changes in temperature, availability of food, water flow, pH or other factors can lower the threshold of impacts from atrazine. Aerial herbicide spraying appears to have a greater environmental effect during the spring months when young salmon and steelhead are emerging from the gravels and feeding on microorganisms and aquatic plants.

The synergistic toxicity of pesticide mixtures: implications for risk assessment and the conservation of endangered Pacific salmon (Laetz, 2009)

Authors conclude that mixtures of pesticides commonly reported in salmon habitats may pose a more important challenge for species recovery than previously anticipated. "…[s]ingle-chemical risk assessments are likely to underestimate the impacts of these insecticides on salmon in river systems where mixtures occur." This means that the existing water quality protections will fail to protect fish, because the standards do not account for chemical tank mixes and the resulting synergistic toxic effects.

DNA damage and effects on antioxidative enzymes in zebra fish (*Danio rerio*) induced by atrazine (Lu-Sheng Zhu, 2011)

Study found that atrazine induces oxidative stress and DNA damage in fish. The study's findings provide further evidence for adverse effects induced by atrazine in aquatic ecosystems

Health effects of pesticide mixtures: Unexpected insights from the salmon brain (Scholz, 2008), and New findings on emerging contaminants: Chemicals in our waters are affecting humans and aquatic life (NOAA, 2008)

Scientists from the American Association for the Advancement of Science (AAAS), reported that pesticides that run off the land and mix in rivers and streams *combine to have a greater than expected toxic effect* on the salmon nervous system than the pesticides would have individually. The scientists concluded that "[c]urrent risk assessments based on a single chemical will likely underestimate impacts on wildlife in situations where that chemical interacts with other chemicals in the environment," and that the findings may have relevance for human health because these toxins act on the nervous systems of salmon and humans in a similar way. The Agency concluded that "Current risk assessments based on a single chemical will likely underestimate impacts on wildlife in situations where that chemical interacts with other chemicals in the environment."

A fish of many scales: extrapolating sublethal pesticide exposures to the productivity of wild salmon populations (Baldwin, 2009)

Results indicate that short-term (i.e., four-day) exposures that are representative of seasonal pesticide use may be sufficient to reduce the growth and size at ocean entry of juvenile chinook. The consequent reduction in individual survival over successive years reduces the intrinsic productivity (lambda) of a modeled oceantype chinook population. Overall, the study shows that exposures to common pesticides may place important constraints on the recovery of ESA-listed salmon species, and that simple models can be used to extrapolate toxicological impacts across several scales of biological complexity.

Contaminant Exposure and Associated Biological Effects in Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) from Urban and Nonurban Estuaries of Puget Sound (Varanasi, et al., 1993)

A National Marine Fisheries Service study of juvenile fall Chinook salmon found that salmon accumulate significant concentrations of chemical contaminants even during relatively short residence times in estuaries, and that juvenile salmon from polluted environments "exhibit abnormalities ranging from subcellular effects to changes in immune function and growth. In many cases the effects alter physiological processes, such that the potential for survival is reduced." Results demonstrate that chemical contaminant exposure in juvenile chinook salmon was sufficient to elicit responses at the chemical, biochemical, and biological level, and provides evidence of linkage between complex mixtures of chemical contaminants in the environment and effects on health and survival of fish.

Demasculinization and feminization of male gonads by atrazine: consistent effects across vertebrate classes (Hayes, et al., 2009)

Atrazine was shown to be an endocrine disrupter for amphibians. Reductions in androgen levels and the induction of estrogen synthesis - demonstrated in fish, amphibians, reptiles, and mammals - represent plausible and coherent mechanisms that explain these effects.

Potential endocrine disruption of sexual development in free ranging male northern leopard frogs (Rana pipiens) and green frogs (Rana clamitans) from areas of intensive row crop agriculture (McDaniel, et al., 2008)

The study assessed a suite of potential endocrine effects in amphibians, including the occurrence of testicular ovarian follicles in male frogs. The proportion of testicular oocytes correlated with a mixture of pesticides and nutrients, particularly atrazine and nitrate, while the number of pesticides detected at each site was also important.

Fact Sheet: Canadian Water Quality Guidelines for the Protection of Aquatic Life. (Canadian Council of Ministers of the Environment, 1999)

In a review of the literature, the Canadian environmental agency found a number of reports describing the effects of atrazine additions to laboratory and field microcosms. In these studies, the introduction of atrazine (50–100 µ g·L-1) had an immediate and significant effect on phytoplankton and vascular plants. This results in negative impacts to fish and other organisms up the food web.

Pesticide May Negatively Affect Estuarine Health (NOAA, 2007)

NOAA National Centers for Coastal Ocean Science researchers have identified detrimental effects of the commonly used herbicide atrazine on phytoplankton—free-floating algae forming the base of the food chain for aquatic animals

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