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PESTICIDE USE IN BRITISH COLUMBIA AND THE YUKON: AN ASSESSMENT OF TYPES, APPLICATIONS AND RISKS TO AQUATIC BIOTA

by

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ABSTRACT

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The Pacific Region (British Columbia and the Yukon) of Canada is characterized by a wide variety of biogeoclimatic zones, an extensive forestry sector, a diverse agricultural industry situated largely in the south, and high human population densities around the Fraser River estuary (Vancouver) and the adjacent Georgia Basin. The many different land-based activities in British Columbia (BC) employ a range of pesticides and application methods. Pesticides used in the past have included persistent, bioaccumulative and toxic compounds, many of which have been eliminated from general use. The majority of current-use pesticides (CUP) registered for use in BC tend to have shorter half-lives, are generally non-bioaccumulative, and are, for the most part, less toxic than their predecessors. Although some studies have characterized certain "legacy" persistent organic pollutants (POPs) in fish, marine mammals, and abiotic compartments in the BC aquatic environment, little is known about the presence and fate of many of the CUP and their impacts on the health of aquatic organisms and ecosystems. In addition, little knowledge exists on the fate and effects of carrier compounds in pesticide formulations and the transformation/degradation products or metabolites of the pesticide active ingredients. During the period 1991-1999, available data indicate that the quantity of pesticides sold or used in BC increased by 19% to over 8,100,000 kg per year. Wood preservatives and anti-sapstains accounted for approximately 82% of the total quantity sold or used in 1999, although a total of 286 pesticide active ingredients were sold or used in BC. We identify in this report 23 CUP as being of potential concern in terms of the health of aquatic (freshwater and marine) ecosystems. These include 2,4-D, atrazine, carbaryl, captan, chlorothalonil, chlorpyrifos, copper chromated arsenic (CCA), creosote, diazinon, diuron, endosulfan, ethalfluralin, fenitrothion, glyphosate, malathion, 2-methyl-4-chlorophenoxyacetic acid (MCPA), pendimethalin, pentachlorophenol (PCP), quintozene, simazine, triclopyr, and trifluralin, as well the undisclosed surfactants used in biological insecticides such as *Bacillus thuringiensis* Kurstaki. We also identify data gaps and anomalies in available information. Many of the CUP that we have identified are heavily used in the Lower Fraser by various land use activities, and have also been identified as environmental concerns by other agencies. More information is required on the use of newer pesticides in BC, particularly for the period 2000 to present. In addition, basic research on the sources, transport mechanisms, and fate of CUP in the environment is needed, with a special emphasis on characterizing the effects of real world exposures on sensitive lifestages of invertebrates, salmon and other fish species, and marine mammals.

RÉSUMÉ

Verrin, S.M., S.J. Begg, and P.S. Ross. 2004. Pesticide use in British Columbia and the Yukon: An assessment of types, applications, and risks to aquatic biota. Can. Tech. Rep. Fish. Aquat. Sci. 2517: xvi + 209 p.

La région du Pacifique du Canada (la Colombie-Britannique et le Yukon) se caractérise par un large éventail de zones biogéoclimatiques, un vaste secteur forestier, une industrie agricole diversifiée et concentrée dans le sud ainsi que de fortes densités humaines le long de l'estuaire du Fraser (Vancouver) et du bassin de Georgia adjacent. Les nombreuses activités d'origine terrestre en Colombie-Britannique (C.-B.) font appel à toute une gamme de pesticides et de méthodes d'application. Les pesticides utilisés dans le passé comprenaient des composés persistants, bioaccumulables et toxiques, dont un grand nombre ne peuvent plus être utilisés de manière générale. La majorité des pesticides d'usage courant (PUC) actuellement homologués en C.-B. ont tendance à avoir une demi-vie plus brève, à ne pas être bioaccumulables et à être, pour la plupart, moins toxiques que leurs prédécesseurs. Quoique quelques études aient caractérisé certains polluants organiques persistants (POP) hérités du passé chez les poissons, les mammifères marins et les compartiments abiotiques dans le milieu aquatique de la C.-B., on sait très peu de choses sur la présence et le devenir d'un grand nombre des PUC et sur leurs impacts sur la santé des organismes et des écosystèmes aquatiques. En outre, il existe fort peu de connaissances sur le devenir et les effets des composés entraîneurs utilisés dans les formulations de pesticides et des produits de transformation/dégradation ou métabolites des ingrédients actifs des pesticides. Durant la période 1991-1999, les données disponibles indiquent que la quantité de pesticides vendu ou utilisée en C.-B. a augmenté de 19 % pour dépasser 8 100 000 kg par an. Les produits de préservation du bois et les produits chimiques anti-tache de sève représentaient environ 82 % de la quantité totale de pesticides vendus ou utilisés en 1999, bien que 286 ingrédients actifs de pesticides soient homologués pour l'emploi en C.-B. Dans ce rapport, nous dégageons 23 PUC qui causent des inquiétudes particulières au niveau de la santé des écosystèmes aquatiques (marins et d'eau douce). Ils comprennent, entre autres les suivants: 2,4-D, atrazine, carbaryl, captane, chlorothalonil, chlorpyrifos, diazinon, diuron, endosulfan, éthalfluraline, fénitrothion, glyphosate, malathion, acide (4-chloro-2-méthylphénoxy) acétique (MCPA), pendiméthaline, quintozène, simazine, triclopyr, trifluraline, arséniate de cuivre et de chrome, créosote, pentachlorophénol (PCP). Ils comprennent également les agents de surface non divulgués utilisés dans les insecticides biologiques tels que le *Bacillus thuringiensis*. Beaucoup des PUC dont nous avons déterminé la présence sont largement utilisés par divers secteurs de la région du Bas-Fraser, et d'autres organismes ont souligné les préoccupations environnementales qu'ils suscitent. Il convient de disposer de davantage d'information sur l'utilisation des nouveaux pesticides en C.-B., notamment pour la période allant de 2000 à aujourd'hui. De plus, il faut mener des recherches fondamentales sur les sources, les mécanismes de transport et le devenir des PUC au sein de l'environnement, en s'attachant particulièrement à la caractérisation des effets des expositions réelles sur les stades de vie sensibles des invertébrés, du saumon et d'autres espèces de poissons et des mammifères marins.

EXECUTIVE SUMMARY

A multitude of pesticides are used in British Columbia and theYukon ("Pacific Region") to control or eliminate unwanted pests, fungi and weeds. Since these chemicals are designed to either kill or affect the organisms in question, risk of adverse health effects in non-target organisms represents a considerable concern. Waterways are particularly vulnerable, since both hydrophobic and hydrophilic pesticides are influenced by hydrologic forces. The Pacific Region of Canada is characterized by a wide variety of biogeoclimatic zones, an important forestry sector, a diverse agricultural industry including concentrated crop and orchard areas in the south, and high human population densities around the Fraser River estuary (Vancouver) and the adjacent Georgia Basin. Characterizing the impact or risk of impact of different pesticides must be initially based upon a consideration of such features, since these differ greatly from other regions of Canada. *No up-to-date list of pesticide quantities used in British Columbia exists, rendering it exceedingly difficult to conduct even a cursory risk assessment on pesticides in the aquatic/marine environment.* As a result, we have relied heavily upon the 1999 Pesticide Use Survey conducted by Enkon Environmental Ltd. for sales of reportable pesticides in British Columbia and caution should be taken as data may be susceptible to survey errors due to inaccurate or lack of reporting by vendors surveyed, and human error during data translation and management.

In this report, we draw on the results of six past and current pesticide prioritization efforts in order to construct a foundation for future studies. These prioritizations include i) a list of eighteen priority pesticides as identified by the Pesticide Management Regulatory Agency (PMRA, Health Canada); ii) pesticides from a Georgia Basin Ecosystem Initiative (GBEI)-Environment Canada (EC) nominating list of toxic substances of concern in the lower Fraser River/Georgia Basin ecosystems; iii) a World Wildlife Fund list of endocrine disrupting pesticides with additions from the Pesticide Action Network (PAN) Europe list; iv) the top 20 pesticides sold or used in British Columbia during 1999 (Enkon Environmental Ltd.); v) a list of 16 pesticides identified as of concern in the context of risks to the health of coastal killer whales; and vi) a prioritized list of pesticides of concern in the context of the altered migratory behaviour of late-run sockeye salmon in the Fraser River watershed during the period 1996-2002. Total sales for the PMRA list ("i" above) decreased in BC by 4.41% to 223,295 kg from 1991 to 1999, at which point these pesticides accounted for 20.43% of total reportable pesticide sales. Sales of seven of the 18 PMRA listed pesticides increased during this period, while eight decreased, and three had no record of use in BC in 1999. Total sales for the GBEI-EC nominating list ("ii" above) increased by 10.3% to 187,866 kg during the period 1991 to 1999, at which point these accounted for 17.2 % of total reportable pesticide sales. Sales of six of the 18 GBEI-EC pesticides increased during this period, while the remaining twelve decreased. The significant use of wood preservatives and anti-sapstain compounds is evident for BC pesticides, since these compounds account for the overwhelming majority of total pesticides sold or used in BC (6,866,528 kg, or 81.7%, in 1999).

Although some studies have characterized certain persistent organic pollutants (POPs) in fish, marine mammals, and abiotic compartments of the aquatic/marine environment in

BC, little is known about the fate of many pesticides and their impacts on the health of aquatic organisms and ecosystems. In addition, little knowledge exists on the fate and effects of carrier compounds in pesticide formulations and the transformation/degradation products or metabolites of the pesticide active ingredients. Our report highlights the need for accessible and up-to-date information on pesticide quantities used in the Pacific Region, with an emphasis on newer pesticides. In addition, further research is required on characterizing the source-transport-fate processes of CUP, and their effects on sensitive lifestages of invertebrates, salmon and other fish species, and marine mammals.

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1.0 INTRODUCTION

This report characterizes the use of pesticides in the Pacific Region (British Columbia and the Yukon, Figure 1) of Canada, with a special emphasis on recent usage and possible adverse effects on biota. While no centralized data clearance centre or database exists, information on pesticide use, applications or sales can be collected in a variety of ways that reflect their use in grain agriculture, orchards and large cash crop farms, forestry, and urban settings including landscaping. Such information is scattered, and obtaining up-to-date information is labour intensive and difficult. Pesticide use is constantly changing and such an analysis must be updated to identify such changes.

Fisheries and Oceans Canada is mandated under the *Fisheries Act*, the *Species At Risk Act* (*SARA*), and the *Oceans Act* to protect fish, fish habitat, marine mammals and species listed under the terms of SARA/Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The deposition of any deleterious substance, such as pesticides, into fish habitat can be considered as a harmful alteration, disruption and destruction (HADD) of aquatic habitat under the terms of the *Fisheries Act*.

In our attempt to characterize the risk of Current Use Pesticides (CUP) to fish and fish habitat, we describe the Pacific Region in terms of its biogeography, hydrology, land use and related pesticide applications. In this way, we aim to provide the reader with an overview of the types of pesticides used in Pacific Region, identify possible pesticides of concern, and consider the potential risks to the aquatic environment, with reference to anadromous salmon, estuaries and coastal areas, marine food webs, and marine mammals.

1.1 THE PACIFIC REGION

The Pacific Region consists of 27,000 km of coastline, and covers an area of 143.2 million hectares (95 million hectares in BC and 48.2 million hectares in the Yukon).

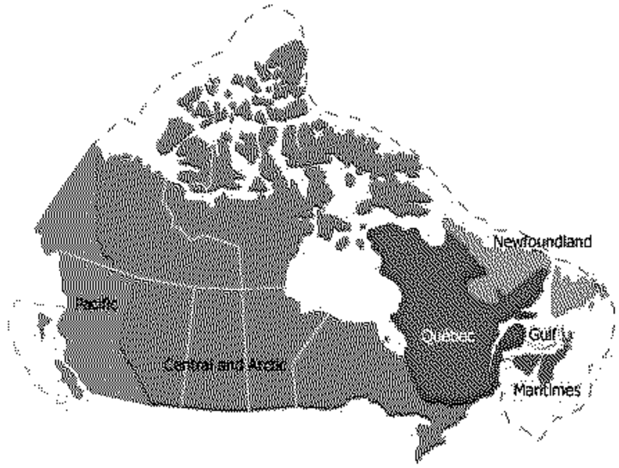


Figure 1: Fisheries and Oceans Canada administrative regions; the Pacific Region consists of British Columbia and the Yukon (Fisheries and Oceans Canada 2003).

1.1.1 Biogeoclimatic Zones of the Pacific Region

British Columbia (BC) is unique compared to other regions in Canada due to its high degree of geoclimatic diversity (Ministry of Sustainable Resources Management 2003). BC has 14 different biogeoclimatic zones ranging from arid deserts to alpine tundra and spruce-willow-birch zones located in the coastal mountains (the two harshest climates of all of the zones) (Figure 2). Climates in the latter two are typically associated with long cold winters, and short cool summers. They occur primarily in the northern portion of BC and into the Yukon. The north-eastern portion of the province is located in the boreal white and black spruce zone and is considered the prairie land of BC.

The central portion of the province is characterized by sub-boreal spruce and typically has severe winters and short, warm summers. This area is also an active forestry area. Just inland, 900 to 1800 meters above sea level in the south and 400 to 1000 meters above sea level in the north, is the mountain hemlock zone. The climate here is characterized by short cool summers and long, cool, wet winter with heavy snow. Again, this area hosts forestry activities. The Engelmann spruce – subalpine fir zone characterizes two-thirds of the province and is recognized by its steep rugged mountainous terrain and moist, snowy, harsh winters, and short, cool summers. Montane spruce occurs in the southern middle portion of BC with long cold winters and short summers and is often associated with wildfires. A very small portion of BC is zoned as bunchgrass and interior Douglas fir. These areas are known as the deserts of BC with typically hot, dry, long summers and cool winters. The coastal western hemlock zone makes up two-thirds of BC's coastline including the Queen Charlotte Islands and Vancouver Island. This is the rainforest of BC and hosts a large forestry industry.

In contrast to BC, the Yukon Territory is characterized by alpine tundra and boreal forest cover. The Territory also has a sub-arctic continental climate with temperature reaching as high as 30°C in the summer and as low as –50°C in the winter (Yukon Department of Renewable Resources 2000). Permafrost is found throughout the region, with sporadic discontinuous patches evident in the south and more extensive discontinuous areas in the north. The average frost free periods ranges from 93 days in the Watson Lake area, to 21 days at the Haines Junction (Yukon Department of Renewable Resources 2000). Frost free periods also vary year by year at various locations. Due to the regions latitude (north of latitude 60°) the Yukon experiences long hours of daylight during the summer.

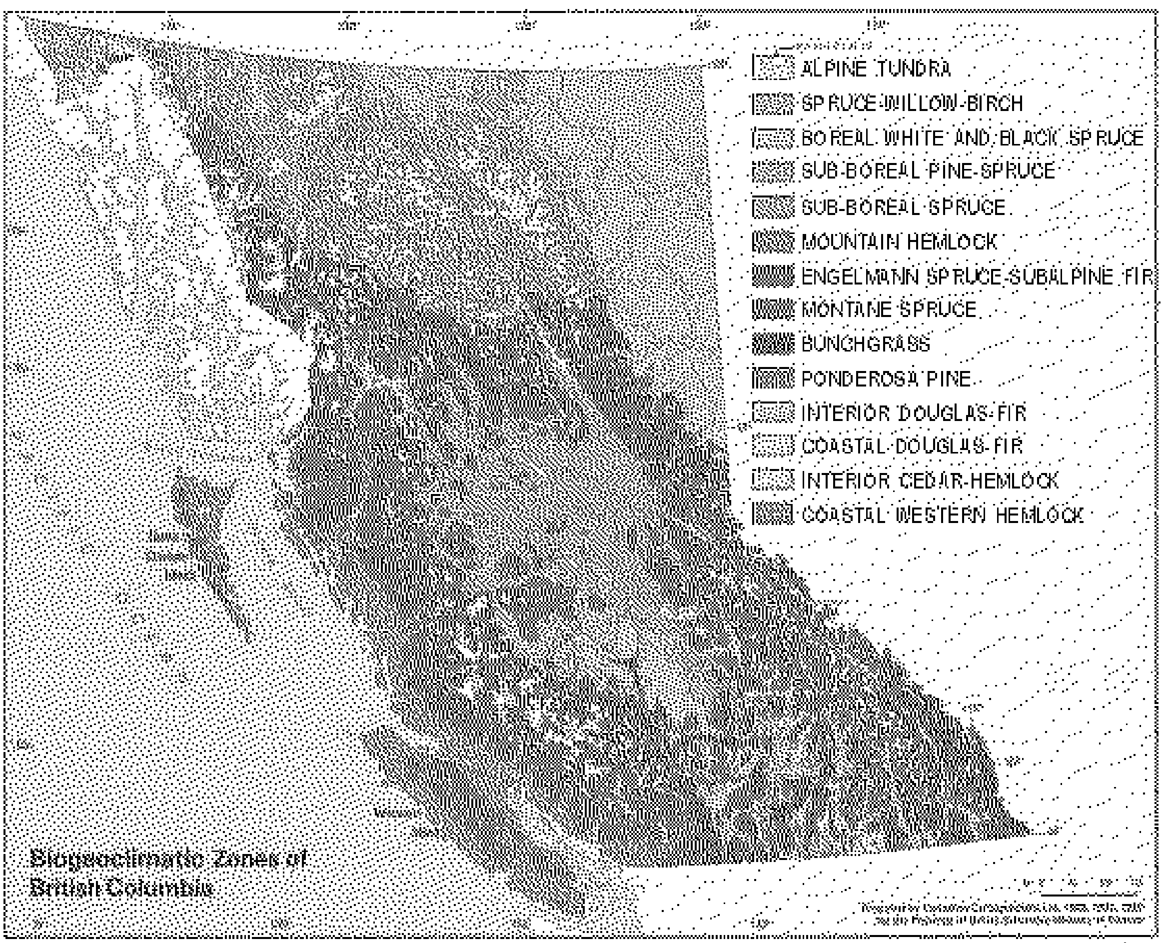


Figure 2: British Columbia is characterized by a wide variety of biogeoclimatic zones (Ministry of Forests 2003a).

The numerous biogeoclimatic zones of the Pacific Region provide for a wide diversity of land use activities. Unlike the often homogenous agricultural crops in the prairies, BC has many crop types within a given area. The forestry industry operates extensively throughout most of the province, and to a lesser extent in the Yukon. In addition, BC's climate, particularly in the southern regions, is hospitable to humans, attracting large populations to small geographic locations (i.e. the lower Fraser Valley and southern Vancouver Island).

1.1.2 Hydrology

Pesticide transport and fate will be discussed in detail in a subsequent section, but understanding the basic hydrology of the Pacific Region will aid in determining the possible sinks and directional flow of the various major watersheds. Major watershed boundaries and topography overlays obtained (Government of Canada 1977) were used to determine a gross estimate of the directional flow of water (Figure 3).

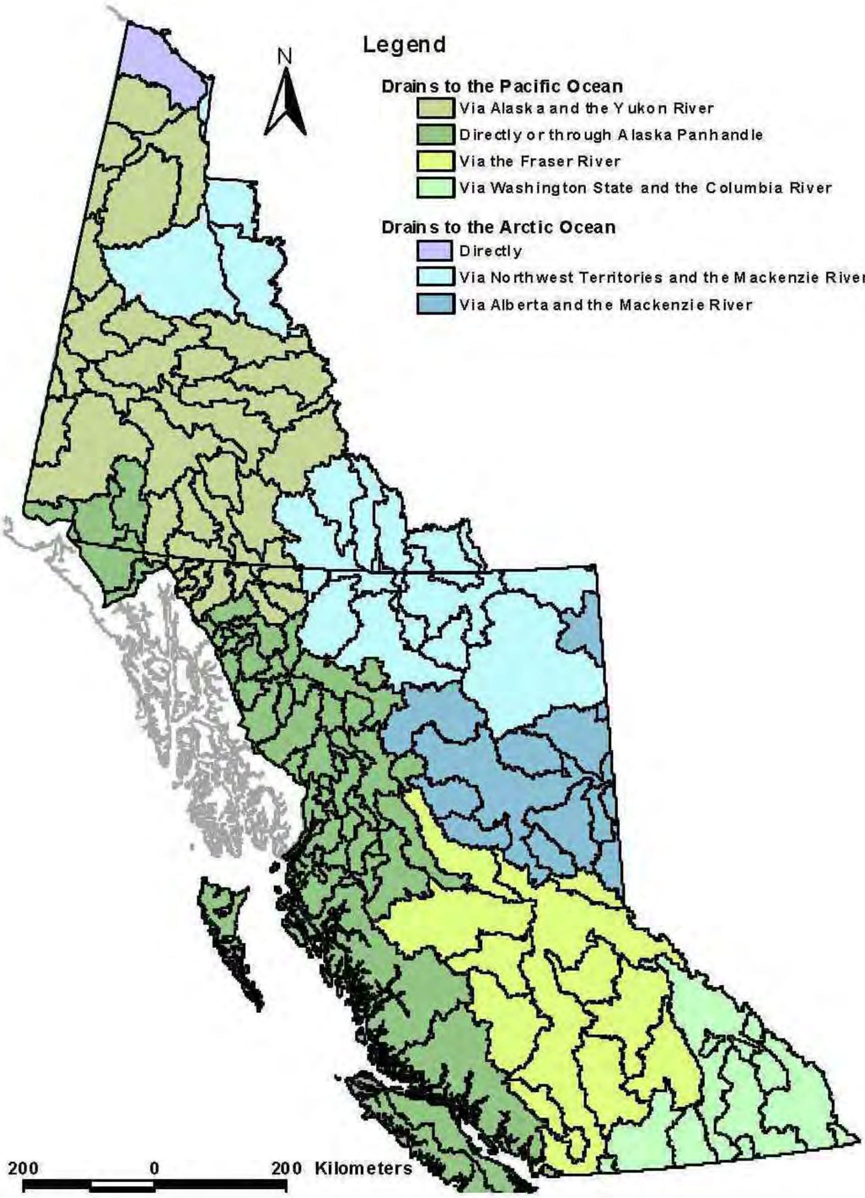


Figure 3: Pesticides will have a tendency to follow hydrologic drainage systems. This map depicts basic watersheds and drainage directions (Battershill 1994; Government of Canada 1977).

1.1.2.1 Yukon Territory

The Yukon River is the second longest river in Canada and drains almost two-thirds of the Yukon Territory. It runs 3,185 kilometres from northern British Columbia to the Bering Sea. The Territory's largest lakes - Kluane, Teslin, Bennett and Laberge - are located near its headwaters.

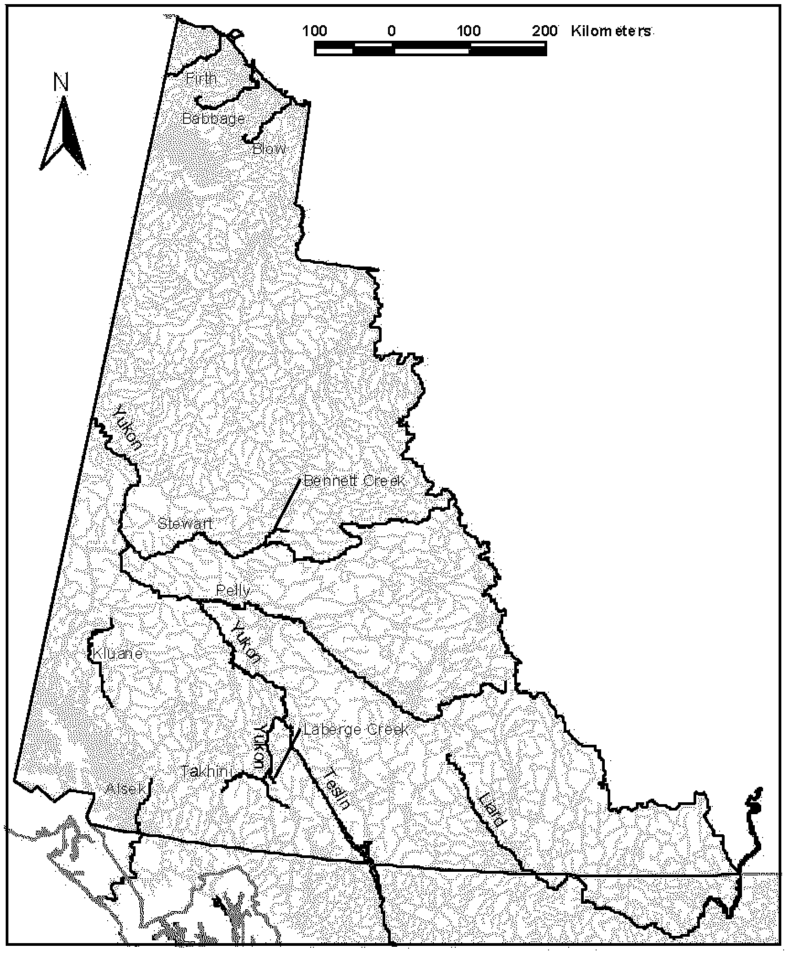


Figure 4: Location of major rivers in the Yukon. Created by Johannessen, D. 2003 with data from Habitat Enhancement Branch GIS Server, Fisheries and Oceans Canada, original data source from Geographic Data BC 1995.

Other major rivers include the Alsek which flows through south-western Yukon to the Gulf of Alaska, the Liard which flows through south-eastern Yukon into the Mackenzie River, and the Pelly which drains the Wernecke and Oglivie mountains in north-eastern Yukon. The Firth, Babbage and Blow Rivers flow through the Yukon's North Slope to the Beaufort Sea (Yukon Department of Environment 2002). The majority of the Yukon's soil based agricultural (excluding greenhouse activities) is situated along the river banks of the Yukon, Pelly, Liard, Stewart and Takhini Rivers. Forestry activities tend to occur in with close proximity to Liard and Rancheria Rivers and Watson Lake in the southeastern region of the Territory.

1.1.2.2 British Columbia

The majority of the outflow in BC is into the Pacific Ocean via numerous inlets and rivers (Figure 3). The most obvious and most studied in terms of contaminants is the Strait of Georgia into which the Fraser River discharges. An in-depth review of the hydrology of BC and salmon rearing habitats provides valuable information on coastal and interior ecology, forestry, and impacts of urban development and agriculture (Brown 2002).

BC has an abundance of primary rivers, the most prevalent being the Fraser River in the Lower Mainland, which the Pitt and Harrison Lakes and the Coquihalla River empty into. In the Southern Interior, the North and South Thompson and Nicola Rivers flow into the Fraser, while the Similkameen, Okanagan and Kettle Rivers all drain into the Columbia River. The Kootenay watershed flows primarily to the United States (Montana and Idaho) via the Kootenay and Flathead Rivers (Figure 3). The Columbia River also flows in this region and drains into Washington State along with Big Sheep Creek.

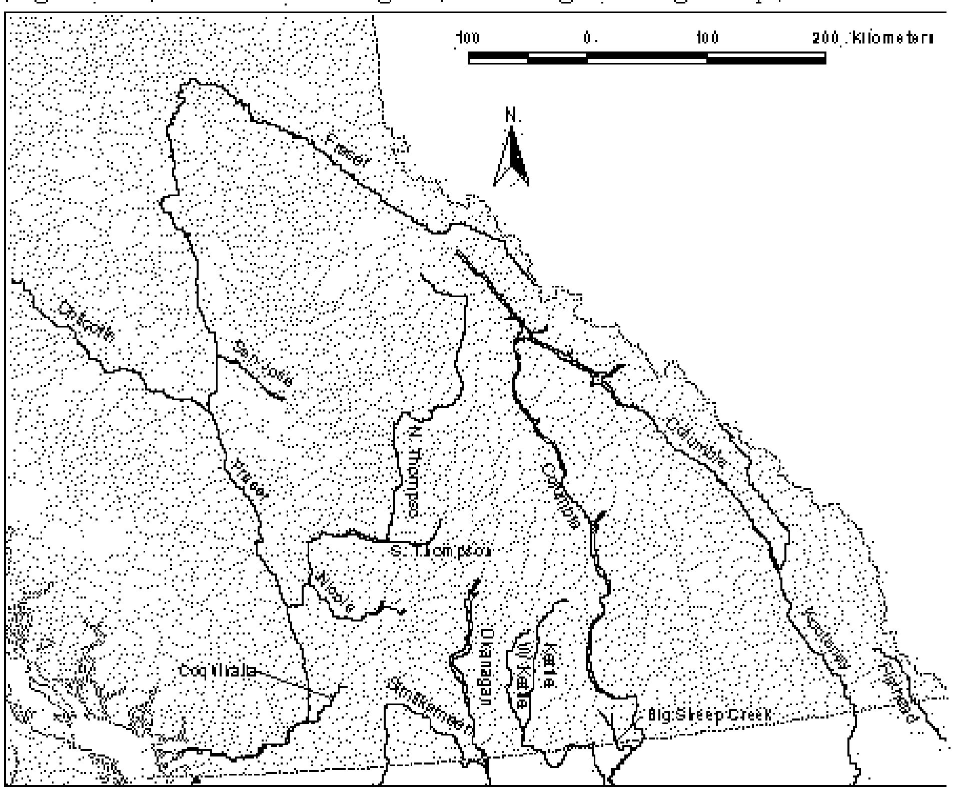


Figure 5: Location of major rivers in southern British Columbia. Created by Johannessen, D. 2003 with data from Habitat Enhancement Branch GIS Server, Fisheries and Oceans Canada, original data source from Geographic Data BC 1995.

The Peace River-Omineca region located in the northeastern portion of BC contains two major watersheds, one that drains into the Northwest Territories (NWT) and the other into Alberta. Rivers flowing to the NWT include the Liard (also present in the Yukon) and Fort Nelson Rivers. The Peace River, and to a lesser extent the Fort Nelson River, drain into Alberta. In the southern portion of the region, near Prince George, the Fraser River flows to the Pacific Ocean. A large glacier in the region (the most southern portion) on Mount Robson provides water that drains into Alberta.

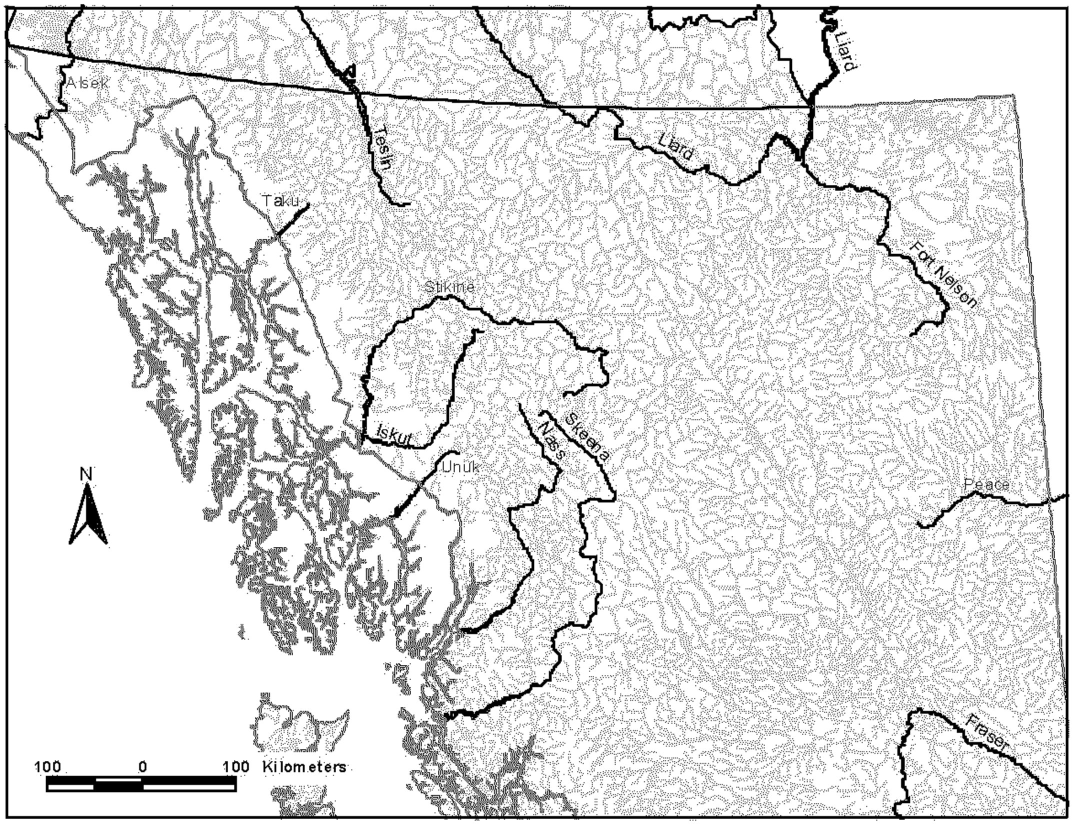


Figure 6: Location of major rivers in northern British Columbia. Created by Johannessen, D. 2003 with data from Habitat Enhancement Branch GIS Server, Fisheries and Oceans Canada, original data source from Geographic Data BC 1995.

In the Cariboo region (central BC), the Fraser River drains Quensel Lake, and the San Jose and Chilcotin Rivers. The Skeena region, along the coast, hosts several rivers which drain into the Pacific Ocean including the Skeena, Nass, Unuk, Iskut, Stikine, Taku, Salmon and Bear Rivers. The latter two rivers also represent a source of glacial melt.

A basic understanding of the hydrology of the Pacific Region, coupled with land use activities in the vicinity of major river systems, provides a foundation for characterizing pesticide risks. Watershed activities such as agriculture, forestry and urban development compromise water quality. Many of the major rivers and tributaries in BC are routinely monitored for nutrient loadings, siltation and some contaminants (Fraser River Estuary Management Program 1996). However, pesticide concentrations are not normally measured due to the high cost of analysis and often low detectability. The waters within the Pacific Region host numerous fish species and provide important spawning and rearing habitats for both commercial and recreationally fished species in addition to biota used for cultural purposes among First Nations.

1.1.3 Land Use

Land use within the Pacific Region may be broken down into urban, forestry, and agricultural lands. The Yukon is characterized by mining activities followed by forestry and urban activities, reflecting biogeoclimatic factors (i.e. permafrost allows for very little agricultural activity in the region) and a small population base (Yukon Department of Renewable Resources 2000). On the other hand, British Columbia has an array of land use activities, all of which cannot be exhausted in this report. However, in contrast with the Yukon, BC has a much larger population base, a diversified agricultural industry and a prominent forestry industry (Figure 7). Land use activities are only grossly identified in this figure (i.e. urban and agricultural land use in the Lower Mainland, urban on the southern tip of Vancouver Island, range and crop land in the Southern Interior, and cropland in the Peace-Omineca region).

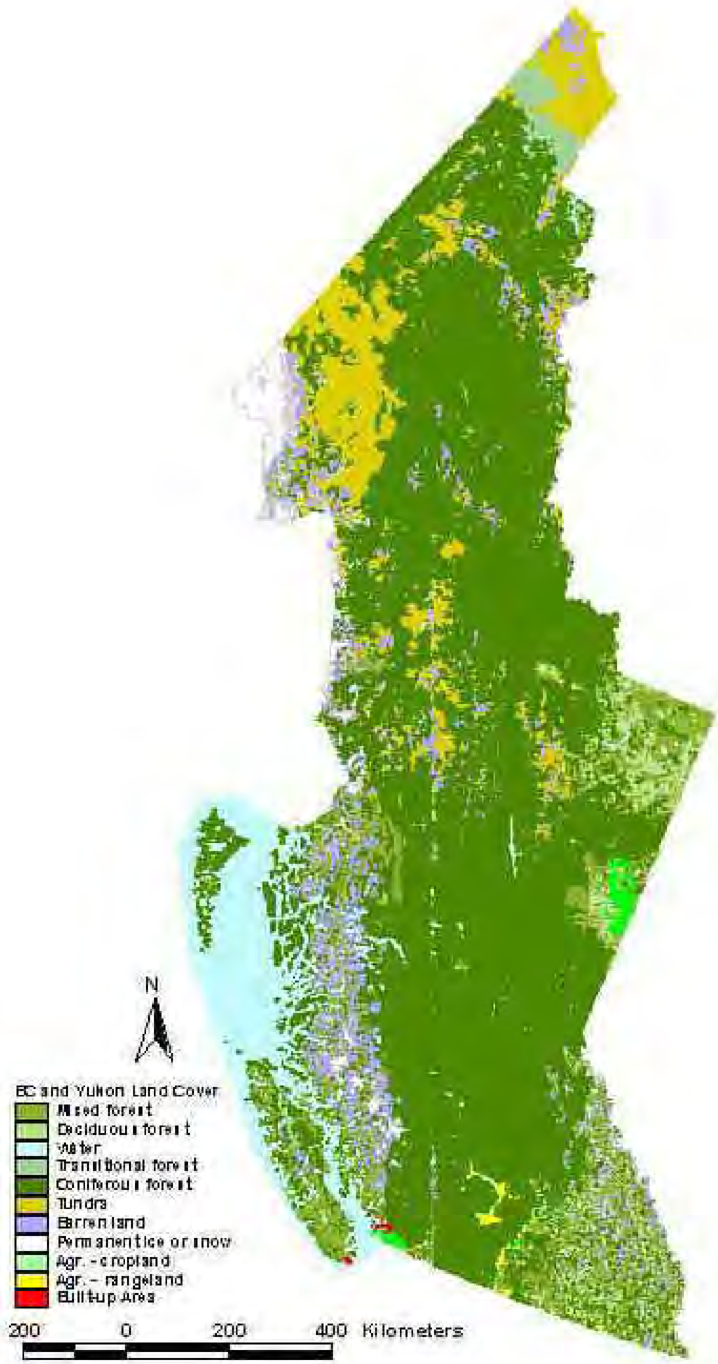


Figure 7: Distribution of land cover and land use activities found in the Pacific Region. Created by Johannessen, D. 2003 with land use data (1992-1993) obtained from GeoGratis.

1.1.3.1 Urban

1.1.3.1.1 Yukon Territory

The Yukon is sparsely populated with 29,841 people (an approximate density of 0.1 per square kilometre) primarily in urban areas (Statistics Canada 2003). The most populated area is Whitehorse with 20,695 people, while Dawson City had 1,251 people in 2001 year (Figure 8) (Statistics Canada 2003).

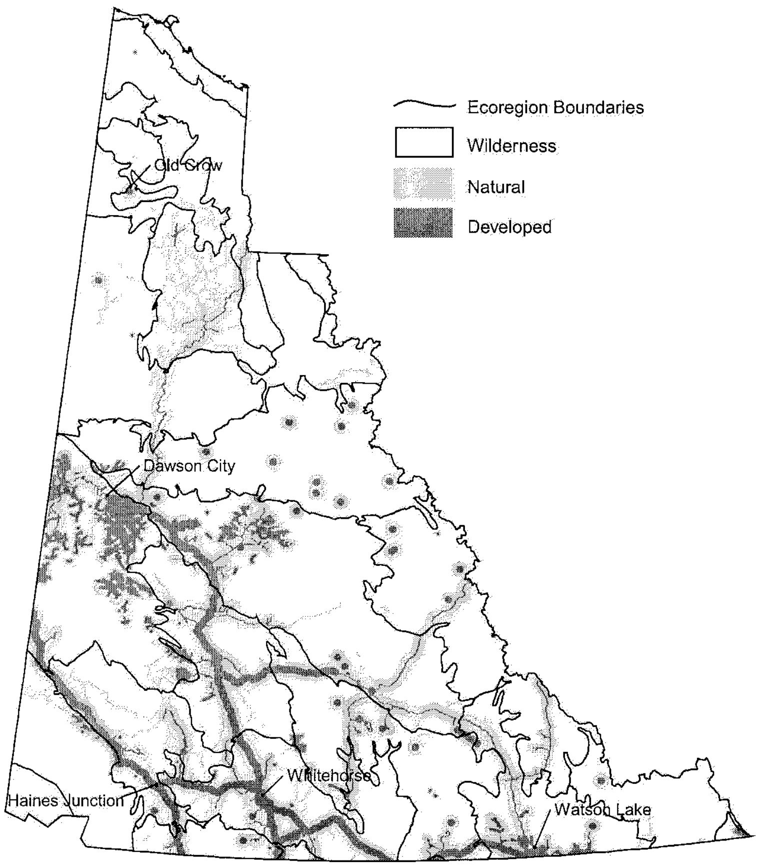


Figure 8: Population distribution based on developed area for the Yukon Territory in 1999. Note developed areas include roadways (Yukon Department of Renewable Resources 2000).

1.1.3.1.2 British Columbia

In contrast to the Yukon's sparse population, BC has over 4 million people with an approximate density of 4.2 per square kilometre (Statistics Canada 2003). The distribution of the census population in BC is shown for 1996 in Figure 9 with approximately 85% of the population residing in urban areas (Statistics Canada 2003).

The majority of the population resides in the Lower Mainland of BC, the south-eastern portion of Vancouver Island, and to a lesser extent the Southern Interior and the southern Kootenay regions.

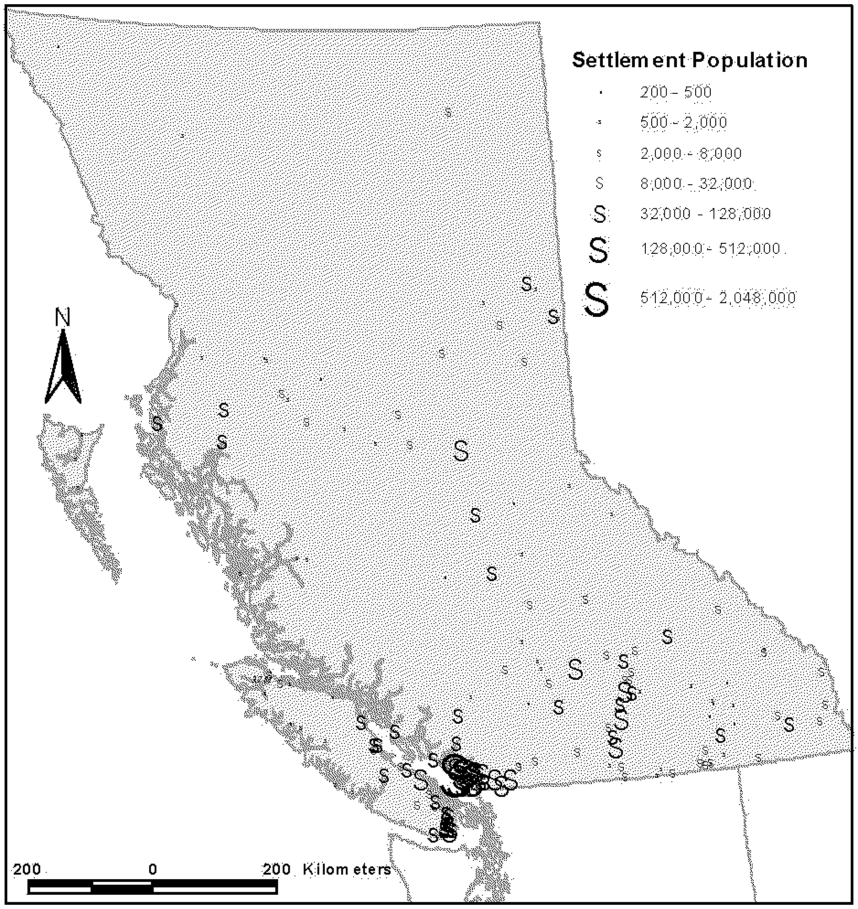


Figure 9: The human population of British Columbia, according to the 1996 census. Source Johannessen, D. 2003. Data source from 1996 census projected to 2000 (Statistics Canada 2003).

Two-thirds of British Columbia's urban population resides in the Lower Mainland and southern Vancouver Island region. Approximately 86% of BC's population lives in urban centers which often lie along watercourses; viable land for agricultural purposes, access to transportation corridors, aesthetics, and hospitable climates attract people to such areas. Population projections for British Columbia indicate that by 2031 the number of residents will reach approximately 6.0 million, up from today's 4.1 million (Ministry of Management Services 2003). In recent years, significant growth has been seen in the Central Okanagan and along the Sunshine Coast.

1.1.3.2 Forestry

1.1.3.2.1 Yukon Territory

Of the 48.5 million ha of forested land in the Yukon, 35 million is expected to remain as original forest, and not be logged (Ministry of Forests 2003a). The Yukon holds a limited potential for development since only 15% of the forested land (75,000 km^2) is considered to be commercially productive (Government of Yukon Canada 2003). The majority of forestry activity occurs along or near the Yukon/BC and NWT provincial boundaries as shown in Figure 10.

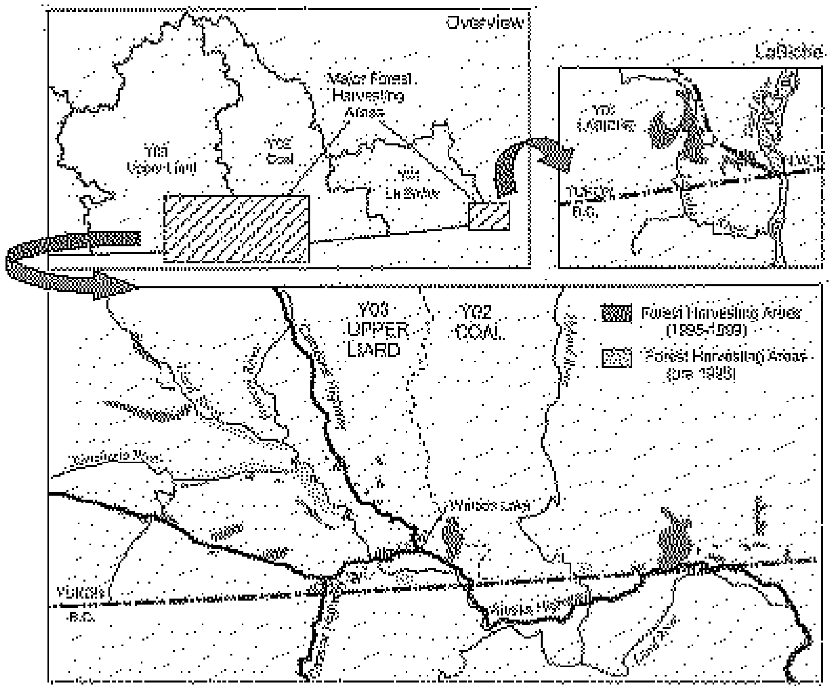


Figure 10: Forestry activity in the Yukon Territory.

1.1.3.2.2 British Columbia

In BC, forested land accounts for approximately 60 million ha (62%) of the total area (Figure 7), 58% of which is reserved for parks or is not suitable for timber production due to environmental sensitivity, in-operable and un-merchantable timber, or are in riparian and old growth reserves (Ministry of Forests 2003b). This leaves a land base of 25 million ha (42%) available for logging, of which approximately 1/3rd of 1% (193,000 ha) is actively logged each year (Ministry of Forests 2003b). In all, there are 37 Timber Supply Areas (TSA – an area of Crown land designated by the Minister of Forests in accordance with the *Forest Act* and managed for a range of objectives including timber production) and 34 Tree Forest Licences (TFL – a tree farm licence is an agreement between the province and licensee which grants the licensee the rights to manage the land

and harvest timber on a defined area of Crown land in accordance with Section 35 of the *Forest Act*) (Figure 11) (Ministry of Forest 2001). Of the land available for timber harvesting, approximately 1% is privately managed forest and 24% is reserved for Crown timber harvesting practices (Figure 12) (Provincial Agricultural Land Commission 2003b).

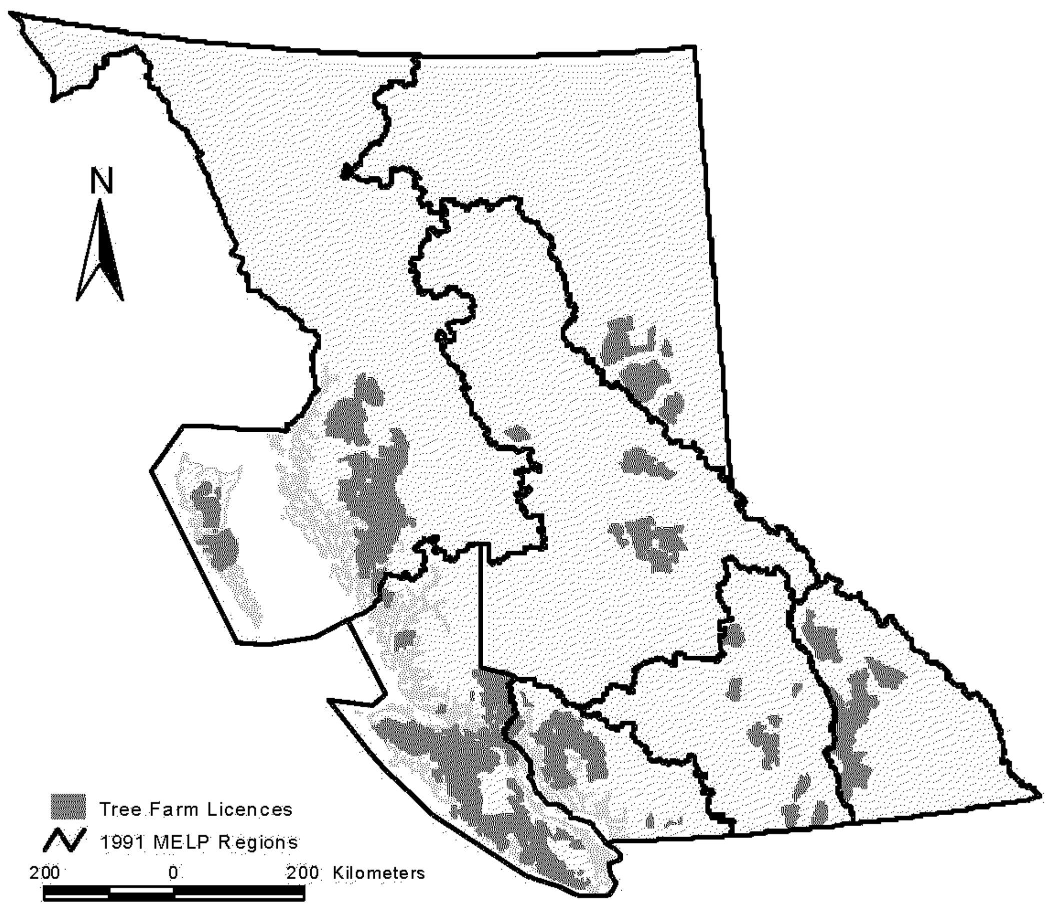


Figure 11: Tree farm licence location map (current to August 2001)(Ministry of Forest 2001).

Pesticides are used on standing crops (trees that have not been logged) and in the treatment of processed logs (i.e. wood preservatives and anti-sapstains). Applications to standing crops are divided into various categories in which permits are issued. These include vegetation management, health protection, rangeland management, rights-of-way, and noxious weed control. Of these categories, vegetation management accounts for roughly 90-99% of the permits issued between 1990-1999, with the exception of the Southern Interior region where forestry health protection was 86% and vegetation management represented 8.8% over the same time period.

According to a report by the Fraser River Action Plan (Fraser River Action Plan 1998), nearly 70% of the softwood lumber industry is located in the Fraser Basin with 14 out of 19 heavy-duty wood preservative facilities operating in this area. In 1997, these facilities were estimated to generate 30,000 cubic metres of toxic surface runoff annually (Fraser River Action Plan 1998).

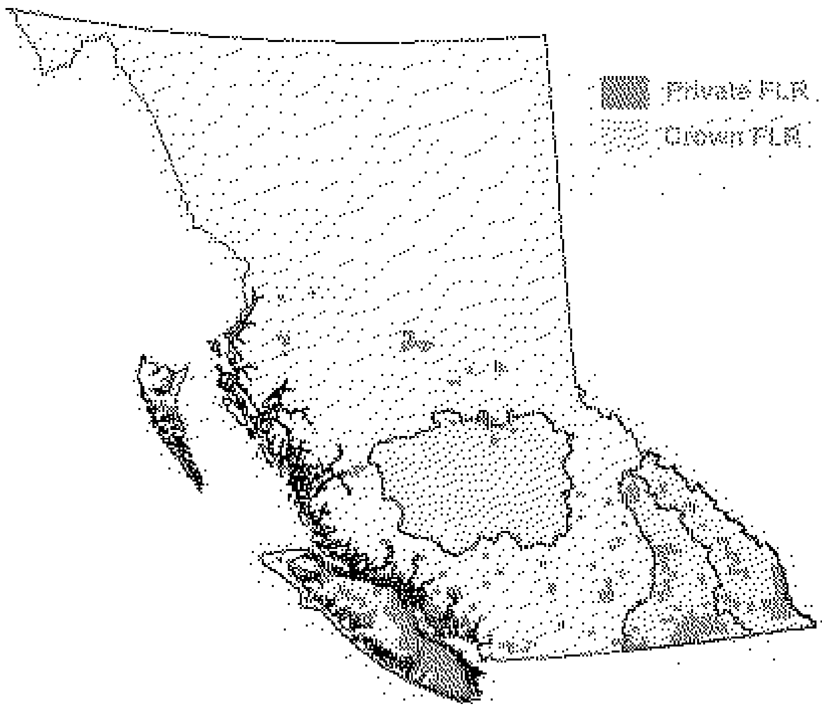


Figure 12: Private and crown forest land reserves in British Columbia (Provincial Agricultural Land Commission 2003b).

The forestry industry is prevalent in most of British Columbia, and to a lesser degree in the Yukon Territory. Forestry is an integral part of the Pacific Region's economy, generating an annual revenue of $1.2 billion in 2001/02 (Ministry of Forests 2002). Infestation of pests and diseases threaten forest health, often leading to treatment of forests with pesticides. Common infestations include bark beetle, spruce budworm, mountain pine beetle, white pine weevil, armillaria and phellinus root diseases, and pine stem rusts. Vegetation management accounts for the majority of the industry's pesticide use with both aerial and ground application methods being used.

1.1.3.3 Agriculture

1.1.3.3.1 Yukon Territory

Less than two percent of the Yukon is suitable for agricultural purposes due to the geography, climate and soil limitations (Hill *et al.* 2000). As of the 2001 Agricultural Census, approximately 60% of the 11,800 hectares is devoted to farmland (Hill *et al.* 2000). Mountainous terrain, and the presence of glaciers and ice fields in some areas, characterize the Yukon region. The majority of soil-based agriculture occurs along the river banks of major river valleys, including the Yukon, Takhini, Pelly, Stewart and Liard Rivers (Figure 13) (Yukon Department of Renewable Resources 2000; Hill *et al.* 2000). The primary agricultural areas are located in the southwest portion of the Yukon, in the rainshadow created by the St. Elias and Coastal Mountains (Yukon Department of Renewable Resources 2000; Hill *et al.* 2000). Approximately 70% of the agricultural farms are located within 100 km of Whitehorse in the Takhini Valley. Other areas of significant activity are located near Dawson City, Watson Lake and Mayo (Yukon Department of Renewable Resources 2000).

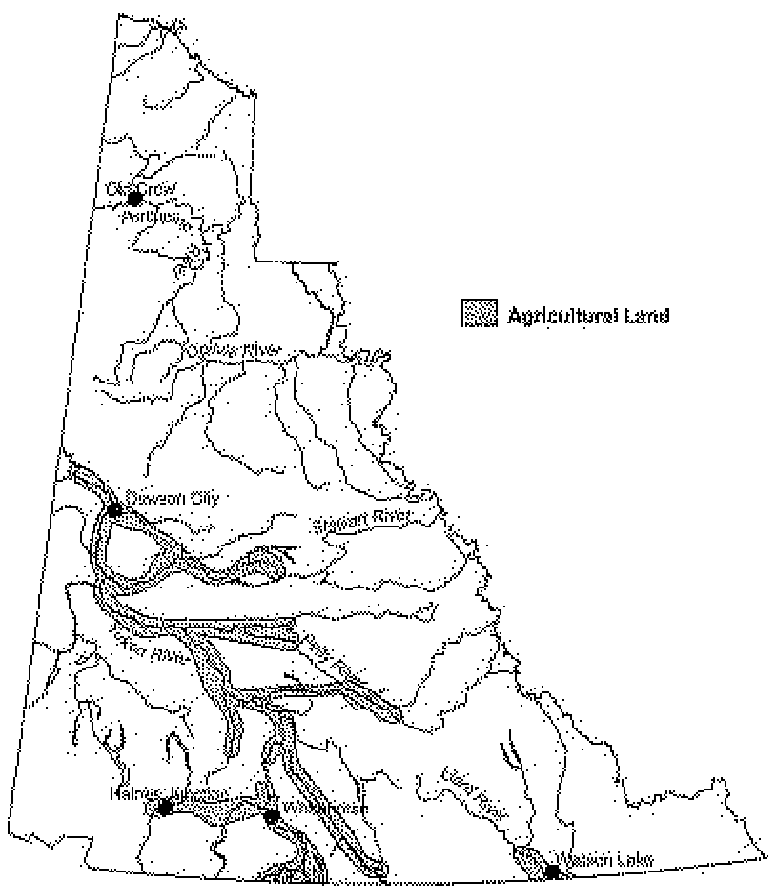


Figure 13: Distribution of agricultural land in Yukon Territory (Hill *et al.* 2000).

Varying temperatures, permafrost, limited growing season (due to limited daylight hours in the winter and long hours in the summer), precipitation, and soil types (low in organic matter and high salinity) have limited the number of viable crops in the area. In 2001, 170 farms were reported with a land area of 29,318 acres (Hill *et al.* 2002). Of the farms reporting total gross farm receipts greater than $2,499, the majority of farming activity was animal production (50%, including cattle ranching and farming, pig farms, poultry and egg production) (Figure 14). However, in terms of crop production (35%), approximately 68% (roughly 4,200 acres) is attributed to the cultivation of tame forage and fodder crops (Figure 15) (Hill *et al.* 2000). Forage production is based on brome grass, timothy and legumes such as alfalfa. Green feed (mainly oats), and to lesser extent barley and fall rye, are secondary in terms of crop percentage (Figure 15) (Hill *et al.* 2000).

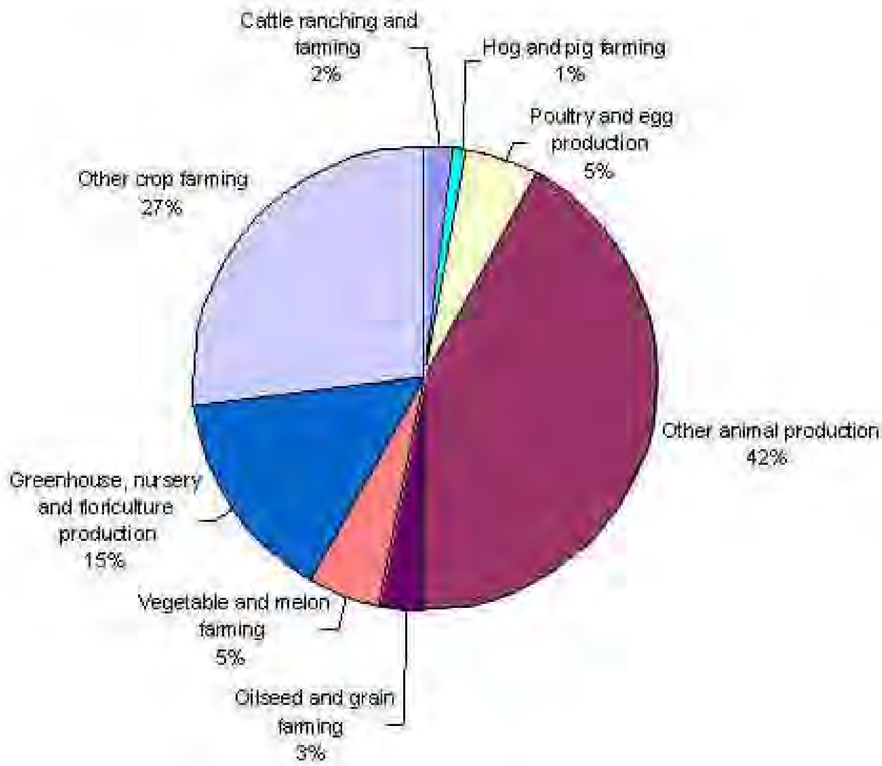


Figure 14: Yukon farm types for farms reporting total gross farm receipts greater than $2,499 (Yukon Executive Council Office 2000).

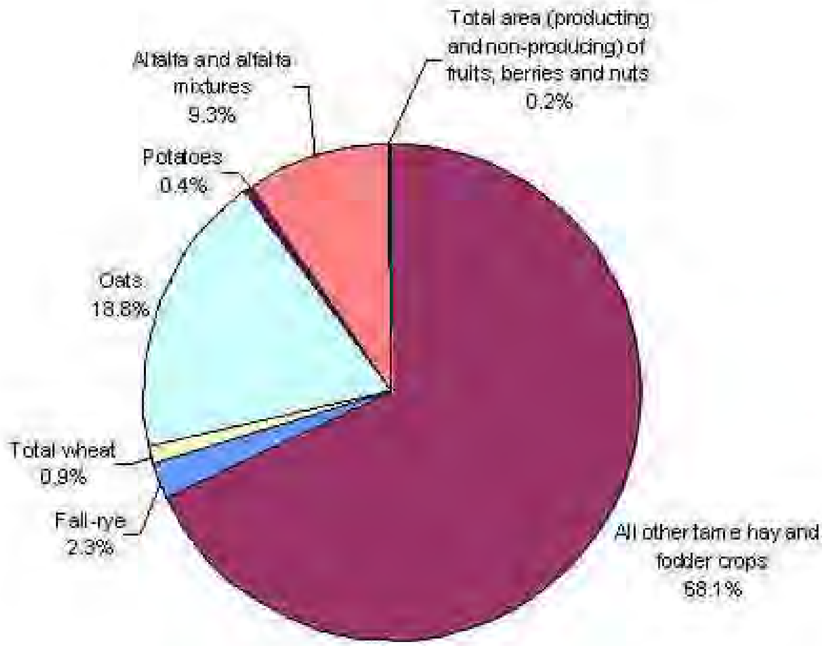


Figure 15: Percentage of agricultural crops grown in the Yukon Territory (Statistics Canada 2001).

1.1.3.3.2 British Columbia

The BC Agricultural Land Reserve (ALR) covers approximately 4.7 million ha (4.8%) of the province (Figure 16) (Provincial Agricultural Land Commission 2003a). This figure provides an overall idea of the distribution of ALR land but does not present the actual agricultural land used as of the 1996 census. Only 2.5 million ha is currently used for agricultural purposes with 788,700 ha (23.9%) devoted to crop production (Figure 17) (BC MAFF 2002). Crop production normally concentrates in the fertile soils of valley bottoms where water is readily available for irrigation and livestock watering. This lends itself to potential water quality issues unless precautions are taken to mitigate impacts (i.e. use of buffer zones, integrated pest management plans). Approximately 24% of the province's agricultural activities occur on private lands in the Lower Mainland, Vancouver Island, Southern Interior and Peace River areas (BC MAFF 2002). Forty-two percent of the best arable lands and 69% of the best pasture lands in BC are located in the Fraser Basin (Nener and Wernick 1997), underlining the potential pesticide risks to aquatic biota in this area.

Figure 16: Distribution of agricultural land reserve in BC in 2000 (shaded areas) (Provincial Agricultural Land Commission 2003a).

BC produces a large variety of crops (Figure 18). Approximately 55% of those grown are for forage primarily spring wheat, and durum wheat (BC MAFF 2002; Statistics Canada 2001). Vegetable crops with large revenues include tomatoes, sweet peppers and cucumbers (all of which are greenhouse grown and represent a small percentage of area utilized and will therefore not be addressed by this report), apples, blueberries, potatoes, ginseng, cranberries, grapes, raspberries, cherries and wheat. Apples alone represent approximately 11% of agricultural output and just over a quarter of the national production (BC MAFF 2002; Statistics Canada 2001). In 2000, five of the top 25 commodities consisted of sweet cherries, greenhouse peppers, raspberries, cranberries and ginseng, which accounted for more than 50% of the Canadian marketed production. Eleven products accounted for more than 25% of Canadian production (BC MAFF 2001). However, the revenue generated by a specific crop does not necessarily reflect the area of land utilized, for instance a small raspberry farm can generate more revenue than a large forage crop. For this reason we focus our efforts on crops having a total area greater than 200 hectares in size with the underlying assumption that aquatic biota will be a greater risk of pesticide exposure from larger agricultural operations.

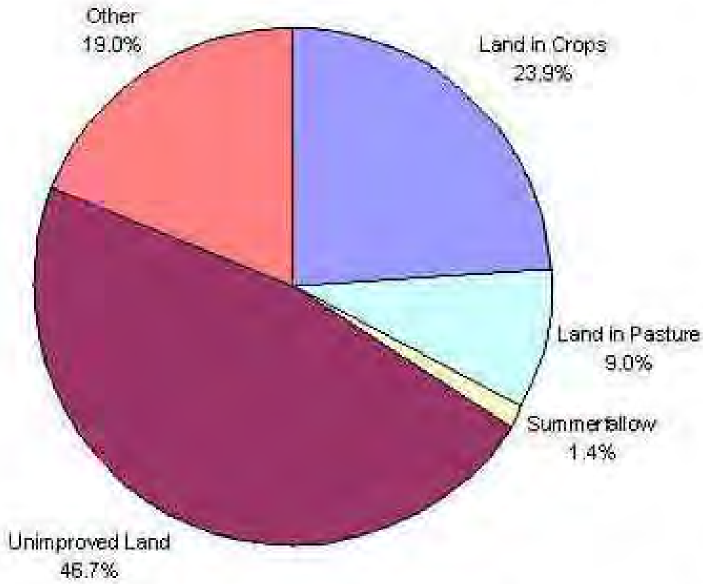


Figure 17: Percentage of agricultural activity in BC by hectare (BC MAFF 2002).

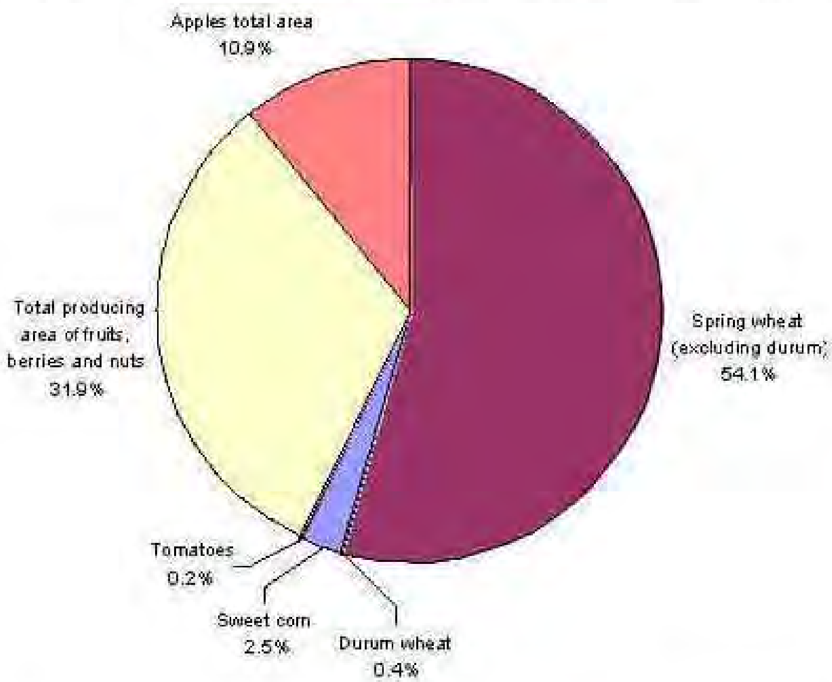


Figure 18: Percentage of crops grown in British Columbia (BC MAFF 2002).

Certain biogeoclimatic zones best suit certain agricultural activities which in turn depicts pest control products used in a given area. The Southern Interior is known for its production of tree fruits and grapes, whereas the Fraser Valley and southern Vancouver Island are more suited for berry and vegetable crops. Most of the province's grain and oilseed crops are grown in the Peace River region Table 1 (BC MAFF 2001). Cariboo and North Thompson/Okanagan are characterized by beef production; more field/forage crop types are therefore grown to feed cattle. The Lower Mainland, south-eastern Vancouver Island and Okanagan-Shuswap areas are characterized by dairy herds and related production. The Lower Mainland is also well suited for hog, poultry and egg production.

Table 1: Agriculture activity (ha) by development region (BC MAFF 2002).

	Development Region Area (ha)*							
	Peace River-North East	Bulkley-Nechako	North Coast	Cariboo-Central	Kootenay	Thompson/ Okanagan	L.Mainland/ Southwest	Vanc. Is. /Coast
Size of Region (millions)	20.8	20.9	11.9	13.2	5.9	9.7	3.7	8.7
Land Actively Farmed	837,000	239,000	13,000	1,046,469 (Cariboo) 242,700 (Fraser Ft. George)	151,677	600,000	110,000	57,000
Percent Agricultural Activity	4%	1%	0.1%	10%	3%	6%	3%	1%
Natural Land for Pasture	282,000	100,000	4,300	298,000	190,000	380,000	29,000	25,000
Hay	56,000	56,000	2,000	0	17,000	42,000	0	0
Other Hay	0	0	0	45,000	0	0	0	0
Improved Pasture	97,000	34,000	2,500	45,000	12,000	35,000	0	0
Canola	25,000	0	0	0	0	0	0	0
Field Peas	3,700	0	0	0	0	0	0	0
Forage Seed	18,000	0	0	0	0	0	0	0
Alfalfa	64,000	20,000	370	21,000	37,000	37,000	0	0
Grains	91,000	11,000	490	7,200	3,800	10,000	3,000	1,600
Christmas trees	51	50	0	200	7,250	600	500	730
Nursery Products	15	40	0	55	175	467	2,000	370
Field Vegetables	60	30	0	65	165	770	5,100	850
Tree Fruits & Nuts	0	0	0	0	460	9,000	600	370
Berries & Grapes	65	0	0	0	34	1,010	6,500	280
Potatoes	0	30	35	44	370	210	2,500	430
Greenhouses (m^2)	12,000	49,000	0	180,000	42,000	280,000	2,000,000	294,000
Mushrooms (m^2)	0	0	0	0	0	0	230,000	0
Sod	0	0	0	0	0	0	500	120
Corn for Silage	0	0	0	0	0	0	6,200	9,636
Sunflowers	0	0	0	0	0	0	0	100

*all in ha except greenhouse and mushroom crops are in m^2.

Much of the agricultural activities in the Pacific Region occur adjacent to waterways, reflecting the fertile soils and readily available water for irrigation purposes. Unlike most of the other regions in Canada, the diverse biogeoclimatic zones found in the Pacific Region, and in particular the province of BC, create a wide range of agricultural activities. The diversity of crop types leads to a wide range of pests and diseases found within the province, and in turn the use of various pesticide types. However, the impacts of pesticides on water quality and effects on biota and their habitat will vary and depend on a range of factors. These include crop type, intensity of operation, physical landscape, soil type, precipitation runoff and patterns, and preventative measures used (i.e. buffer zones and Integrated Pest Management (IPM) techniques).

1.2 FATE AND TRANSPORT OF PESTICIDES IN BRITISH COLUMBIA AND YUKON TERRITORY

Pesticides are used in numerous applications throughout the Pacific Region to control insects, weeds, and fungi in urban, agricultural and forestry settings. These pesticides are generally targeted for terrestrial use; however, some are also used in the aquatic environment (i.e. to control mosquito populations and algal growth, or as antifoulants on aquaculture nets or ship hulls (which are not discussed here)).

Pesticides may enter waterways either intentionally or unintentionally, and may orginate from "point sources" or "non-point sources". Point sources include the direct application, spilling, or dumping of pesticides into a water way or into terrestrial areas adjacent to a waterway. Direct applications may include the use of herbicides to control waterweeds, pesticides to control mosquito larvae, and overspraying from the aerial application of pesticides during forestry and agriculture operations.

Non-point sources of pesticide contamination generally have a more complex transport mechanism by which they may enter waterways (Figure 19) (Macdonald *et al.* 2002; Macdonald *et al.* 2003; Grant and Ross 2002). Once a pesticide enters the environment, it may be transported to other regions depending largely on its chemical properties (i.e. volatility, solubility, and breakdown products). Equally important in transport and fate are weather conditions, soil type, topography, the amount of organic matter in the soil, and the distance by which the chemical must travel to reach the water table.

To complicate the issue, the breakdown products of pesticides, or metabolites, present new challenges for understanding health and environmental effects of pesticides. Pesticide physical properties and behaviour characteristics have been well documented in a laboratory siting but are based primarily on specific products or active ingredients. Little is currently understood about the nature and environmental occurence of pesticide breakdown products in their natural environment, their interactions with other (multiple) compounds, and their potential health and environmental effects, especially with regards to newer pesticides and numerous pesticide inputs within a small geographical area.

Sales data is often used as an indicator of pesticides most likely to be detected in stream waters. However, additional factors such as the chemical properties of the pesticides used, usage, application timing and method, and proximity of application to streams and other waterways play important roles in the probability of a pesticide entering and compromising water quality. Many of these factors are poorly understood *in situ* and even more so cumulatively.

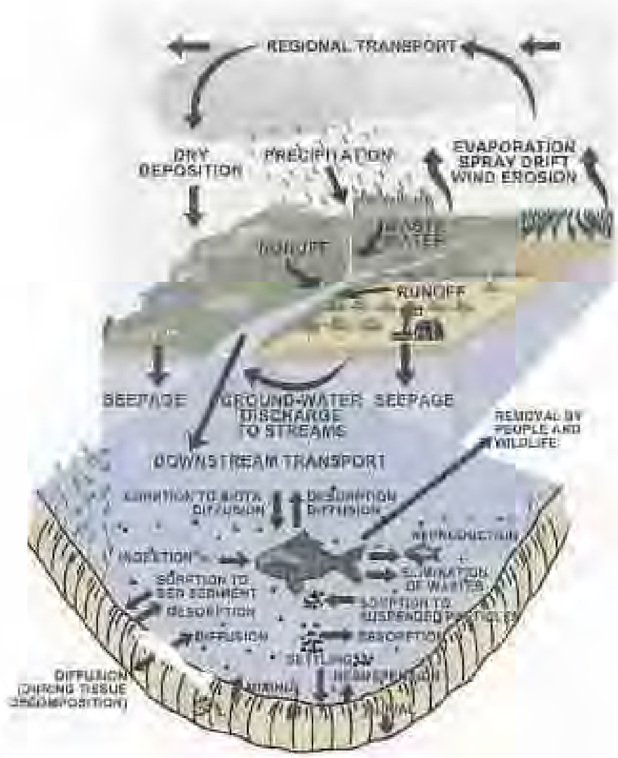


Figure 19: Mechanisms of pesticide transport into the aquatic environment following application to a terrestrial area (United States Geological Survey 1992) modified from (Majewski and Capel 1995).

1.2.1 United States Water Sampling Studies

Studies of urban and agricultural watersheds have been conducted throughout the United States to assess for the presence of pesticides. A study conducted by the United States Geological Survey (USGS) from 1996 to 1998 in Puget Sound found herbicides to be commonly detectable in agricultural stream surface waters. Among the most commonly detected were atrazine, simazine, prometon and tebuthiuron. In urban streams, detection rates were highest for insecticides including carbaryl, diazinon, and malathion. Large rivers were found to integrate the effects of urban and agricultural influences but at lower concentrations due to the effects of larger water volumes and the high-quality water from forested headwaters (Bortleson and Ebbert 2000). The same study also demonstrated that pesticides affected groundwater quality. Shallow wells were found to have a higher detection rate than deeper wells (>100 feet).

A similar study in Puget Sound (1987-1995) by the National Water Quality Assessment (NAWQ) Program found that 2,4-D was the most widely detected and used herbicide, as well as dicamba and the insecticide diazinon (Bortleson and Davis 1997). In general, more pesticides were detected in urban streams than agricultural streams. The detectability of pesticides reflected the environmental persistence of the compound in question, and the analytical methods used. In Puget Sound, domestic pesticide use is nearly three times as great as agricultural use, explaining higher detection rates in urban streams.

In 1994 and 1996, the Washington State Pesticide Monitoring Program conducted surface water sampling at various sites west of the Cascade Mountains, as well as fish tissue and marine mussel sampling in 1995 (Johnson and Davis 1996; Davis *et al.* 1998). Agriculture (dry land and irrigated), orchards, urban and forest land use activities were examined, and 161 pesticides and their breakdown products were measured in samples. In all, 33 pesticides and breakdown products were detected in 1994 and 32 in 1996 with the most frequent being 2,4-D, diazinon, dichlobenil, pentachlorophenol (PCP) and simazine (in 1994), and 2,4-D, 2-methyl-4-chlorophenoxy propionic acid (MCPP), dichlobenil, bromacil and PCP (in 1996) (Davis 1996; Davis 1998). In both years a number of pesticides were found at levels which exceeded US Environmental Protection Agency (EPA) aquatic life criteria. Among these were DDT, DDE, azinphosmethyl, and chlorpyrifos. In the 1994 study, carbaryl, diazinon (and 1996), and malathion exceeded the Nation Academy of Sciences recommended maximum concentration to protect aquatic life and wildlife (Davis 1996). Orchard samples had levels of azinphosmethyl, chlorpyrifos, DDT, diazinon, carbaryl, malathion, and endosulfan in waters either adjacent to, or which ran through the orchard (Davis 1996). Cranberry bogs, in particular, had a high number and frequency of detected pesticides (Davis 1996; Davis 1998). In all, it can be concluded that land use does affect the concentration of herbicides found in surface waters (Larson *et al.* 1999; Black *et al.* 2000).

1.2.2 British Columbia Water Sampling

Environment Canada is the primary agency involved in pesticide monitoring and effects testing; much of this information has been archived and can be found on their website at http://www.waterquality.ec.gc.ca. In all, Environment Canada has 31 stations throughout BC most of which are found in the southern reaches. Monitoring is conducted for a variety of parameters including physical properties, nutrients and organic contaminants. To the best of our knowledge no currently used pesticides have been detected in these sites however it has not been clearly determined if these pesticides are in fact being tested for.

Several other water sampling studies have also been conducted in British Columbia, with most focusing on the lower Fraser Valley (Nener and Wernick 1998b; Nener and Wernick 2000; Nener and Wernick 1998a; Nener and Wernick 1997). Environment Canada conducted surveys from 1985 to 1987 and detected pesticides in both water and sediment samples collected in agricultural ditches that lead to the lower Fraser, Nicomekl, and Sumas Rivers (Wan 1983; Wan 1989; Wan *et al.* 1994; Wan *et al.* 1995). Pesticides detected included azinphosmethyl, diazinon, malathion, endosulfan (at high levels; average 18 µg/kg in ditch water), parathion, dimethoate, and fensulfothion found in a combination of water and sediment samples (Wan 1983; Wan 1989; Wan *et al.* 1994;

Wan *et al.* 1995). The Fraser River Action Plan (FRAP) has also conducted a study of the streams in the lower Fraser Valley (Fraser River Action Plan 1999). This report represents a valuable resource of stream summaries and details the physiography, fisheries resources, activities and land use, and watershed planning issues associated with each stream.

1.2.3 Atmospheric Deposition

A study by the USGS-NAWQA examined the detection frequencies of pesticides in both air and rain samples across the United States. Despite being banned in North America in the 1970's, many persistent organochlorines are still detected in air as they continue to be used in countries overseas. Organophosphate compounds, which are generally less persistent but are more widely used today, were also detected in air, rain and fog samples. Those detected included 2,4-D, chlordane, chlorpyrifos, diazinon, endosulfan, methyl parathion, malathion, methidathion, parathion and trifluralin (United States Geological Survey 1995). Triazine and acetanilide, herbicides (including alachlor and metolachlor) were found predominately in rain samples in a few mid-western states (United States Geological Survey 1995). In addition, seasonality played an important role. Local concentrations of herbicides were found to correlate to local use with the highest concentrations detected in air and rain during the spring and summer months, which coincides with application times and warmer temperatures (higher rate of volatilization). Insecticides were detected at higher concentrations in air, rain and fog during the autumn and winter in areas of high use such as California, where stone-fruit orchards are sprayed when trees are dormant (United States Geological Survey 1995).

In the lower Fraser Valley of BC seasonal variation in pesticide concentrations was evident through concentrations detected in both dry air and rainfall samples; a total 28 chemicals were detected in dry air and eight in rainfall (Belzer *et al.* 1998a). However, not all of the chemicals detected were attributed to local agricultural activities which the study was intended to monitor. A few of the pesticides detected were not registered for use in Canada, supporting the notion of the atmospheric transport of chemicals from other locations and possibly from great distances (Belzer *et al.* 1998a). In another instance during the same study, a peak of 2,4-D was detected in air samples at two sites in February 1996 at which time 2,4-D applications are not commonly made. A back trajectory was calculated at ground level and at 1000m alitutude. The ground level plot appeared to orginate in the direction of the Imperial Valley in southern California. According to Agriculture Canada it was found that it is common practice in California during the month of February to treat seeds with 2,4-D before early planting (Belzer *et al.* 1998a). This event confirms the potential for modern/common use pesticides to be atmospherically transported to other regions. Pesticides detected most frequently and at high concentrations at Agassiz and or Abbotsford sample sites included 2,4-D, 2,4,5-trichlorophenoxypropionic acid (TP), atrazine, captan, diazinon, dicamba, dichlorvos, dieldrin, dinoseb, heptachlor, malathion, mevinphos, and terbufos.

1.2.4 A Pacific Region Context

BC possesses the highest marine biodiversity in Canada, due in part to its biogeoclimatic variation, extensive coastline and related oceanographic features (Ministry of Sustainable Resources Management 2003). As previously discussed, pestcide contamination of stream sediments, water and fish strongly correlates with heavy pesticide use in adjacent areas (Black *et al.* 2000; United States Geological Survey 2001; Dubrovsky *et al.* 1998; United States Geological Survey 1992). Furthermore, urban and agricultural areas often contain sensitive or critical fish habitat (i.e., the lower Fraser River), including spawning streams for salmonids, or intertidal habitat for shellfish and assorted fish species (Warhurst 1995). Coastal areas also tend to be heavily utilized by various marine mammal species, some of which have been exposed to persistent chemicals through biomagnification processes in marine food chains (Simms *et al.* 2000; Ross *et al.* 2000; Ross *et al.* 2004).

In the context of the Pacific Region, snow packed mountains are also of interest in the discussion of pesticides as various chemicals are transported (locally and internationally) through atmospheric processes and can accumulate in mountainous regions (Blais *et al.* 1998; Belzer *et al.* 1998b; Lichota *et al.* 2004; Blais *et al.* 2001; Eisenreich *et al.* 1989; Wilkening *et al.* 2000). An assortment of pollutants, including POPs, can travel from Eurasia on the mid-latitude westerly winds to the Pacific Ocean basin and across to North America where they precipitate out in the cool moist air in the mountains. During warmer weather, seasonal melting and runoff generate an influx of contaminants into the streams, rivers and lakes of low altitude areas of the Pacific Region (Blais *et al.* 2001). This is of particular concern in the BC/Yukon region since high levels of organochlorines have been detected in burbot and lake trout and in eggshells of various fish eating birds (Muir *et al.* 1990; Elliott *et al.* 1989; Blais *et al.* 1998; Macdonald *et al.* 2000).

The deposition of semi volatile organochlorines increases with elevation, as do concentrations in fish, with levels approaching those which trigger health advisories (Donald *et al.* 1998; Blais *et al.* 1998; Donald 1993).

Terrestrial use of pesticides is of concern to Fisheries and Oceans Canada since fish-bearing streams and the marine environment often represent sinks for pesticdes and other contaminants. Pesticides can affect marine organisms either directly through exposure, bioaccumulation and/or biomagnification processes, or indirectly through effects on food web dynamics. Terrestrial pesticide applications from forestry, agricultural and urban activities affect water and sediment quality for varying lengths of time and can affect non-target species including aquatic and marine biota.

1.3 SENSITIVE LIFE STAGES AND RISK OF ADVERSE EFFECTS

The purpose of this section of the report is to identify aquatic species and/or life stages which may be particularly vulnerable to the effects of pesticides that enter their habitat in the Pacific Region.

Pesticides may have a direct or indirect effect on fish and invertebrate populations and their habitats. Johannessen and Ross (2002) discuss in detail the risk of effects of contaminants on sockeye salmon. This includes neurological effects including acetylcholinesterase (AchE) inhibition, direct olfactory effects, endocrine disruption, osmoregulatory disruption, immunosuppression, and developmental effects, as well as the reduction in availability of prey for various predators as a consequence of pesticide exposure. Effects may also vary depending on the stage of development of the organism and the length of exposure to a pesticide.

Of particular concern over the past decade are the late-run sockeye salmon stocks. Figure 20 highlights spawning areas of the Fraser River late-run sockeye stocks. Similar maps are also available for other salmon and trout species and are obtainable from the BC Ministry of Agriculture, Food and Fisheries (BC MAFF) or the BC Ministry of Sustainable Resources Management (BC MSRM). Land use within this spawning region is a mixture of urban, forestry, and agriculture with high pesticide use. Late-run sockeye are of concern due to their decrease in population over the past decade and their economic importance to BC fisheries. Three other sockeye complexes that occur in the Fraser Valley include the Early Stuart Complex, Early Summer Complex, and the Summer Complex. Similar spawning maps are available on the Fraser River Aboriginal Fisheries Society website at http://www.frafs.ca/background/sock_bak.html#Stock.

Four scenarios that may explain a possible contaminant related change in migratory behaviour of Fraser River late-run sockeye are (Johannessen and Ross 2002):

1) Exposure of salmon eggs, alevin and/or fry to chemicals in their microenvironment or spawning habitat affecting their long term development.
2) Exposure of salmon smolts to chemicals in their food or environment in the freshwater, estuarine, and coastal habitats leading to long term effects.
3) Exposure of salmon juveniles and adults to chemicals through the consumption of prey in coastal BC and the North Pacific Ocean leading to long term effects.
4) Exposure of returning adults to chemicals as they enter the Strait of Georgia or Fraser River plume, causing an almost immediate behavioural response.

In the context of pesticide use, scenarios one and two may be considered more likely as most newer pesticides do not persist in the aquatic environment or become too dilute to detect once they enter larger rivers and the marine environment (Bortleson and Ebbert 2000). However, in watershed streams and creeks, pesticides may be highly concentrated, especially after the first rainfall following pesticide application when a pulse of pesticide enters streams and ditches.

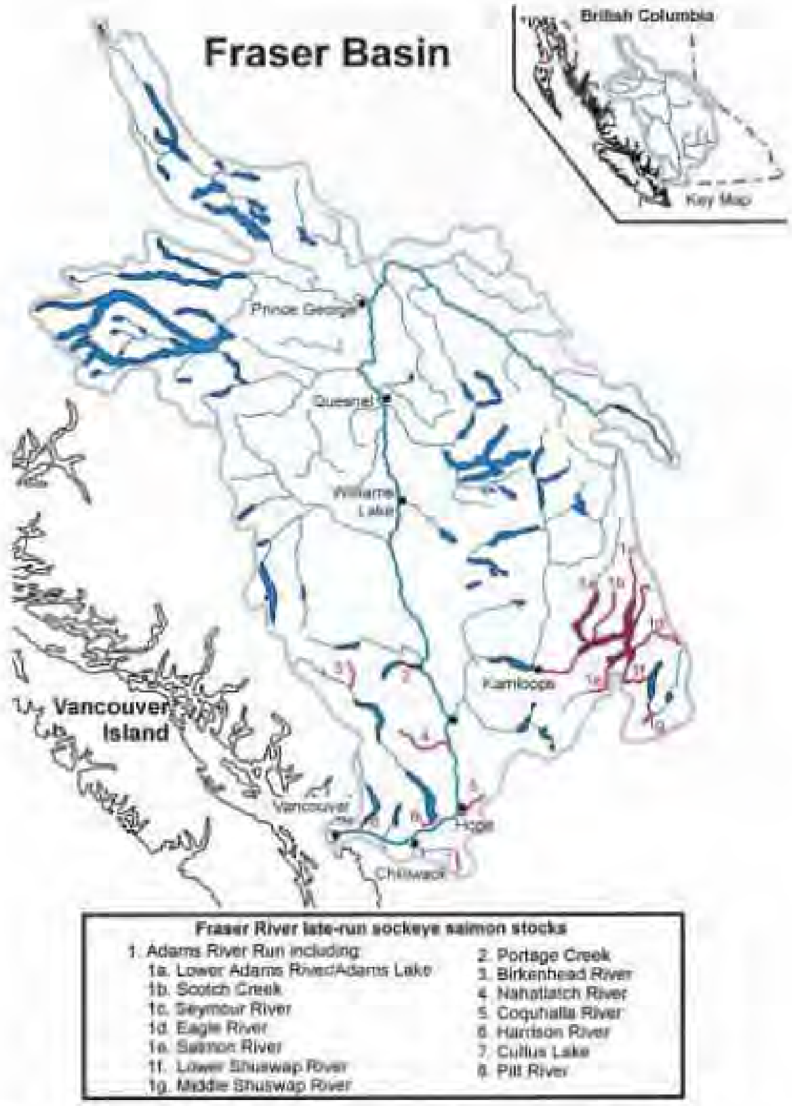


Figure 20: Spawning areas of the Fraser River late-run sockeye stocks (Fraser River Aboriginal Fisheries Secretrait 2003).

Salmon are commonly used as environmental indicators by the BC Ministry of Water, Land and Air Protection (BC MWLAP) due to their importance to the cultural, economic, social and political aspects of life in British Columbia (BC MAFF 2001). The percentage of salmon stocks deemed extinct, at moderate to high risk of extinction, or of special concern is used to determine the environmental state of BC waters (BC MAFF 2001). There are five salmon and two trout species which are examined by BC MWLAP: chinook, chum, coho, pink and sockeye salmon, as well as, steelhead and cutthroat trout. Each species is widely distributed in the province, with the exception of the northeastern portion (Peace-Omineca region). Interestly, cutthroat are found only in Lower Mainland waters and chum are the only salmon species found in the northeast portion of the province near Fort Nelson (Fisheries and Oceans Canada - Habitat and Enhancement Branch 2003).

The Fraser River supports the world's largest salmon runs, and is responsible for over 50% of the salmon produced in BC (Fraser River Action Plan 1999). The lower Fraser Valley represents less than 5% of the total area of the entire Fraser Basin; however, it supports the production of approximately 80% of the Fraser River's chinook and chum, 65% of its coho, 80% of its pink and a substantial amount of the sockeye stocks (Fraser River Action Plan 1999). Table 2 provides a brief overview of the species, spawning times and locations of the various salmon and trout species found in the lower Fraser Valley.

Table 2: Salmon and trout species found in the Fraser River, associated spawning times and location, migration timing and distinguishing traits.

Species	Spawning Time	Primary Spawning \ Rearing Locations	Rearing Duration/Location	Age and Timing of Migration to Freshwater
Sockeye	Late summer or fall	Harrison and Pitt Lakes; Chilliwack system and Cultus Lake.	Varies 1 year (young); 2-3 years (others).	4-5 years, usually between May-October.
Chinook	Spring, fall and winter runs	Chilliwack River, also Little Campbell, Nicomekl, Serpentine, Upper Pitt, Harrision and Coquihalla rivers.	3-4 months but up to 1 year. Many juveniles from upper Fraser River move through and rear in lower reaches (in sloughs and estuarine channels) before migrating to sea.	2-7 years.
Coho	October to late February	Very small tributaries in Lower Fraser frequently unmapped. Scattered spawning and rearing distribution. Natal tributaries include sloughs and tidal channels of Fraser River estuary.	1-2 years. Migrate to sea April-July.	2-3 years.
Pink	Odd years, mid July - late Oct.	Within the Fraser River mainstem.	Migrate to sea shortly after emerging from spawning bed.	18 months. Have a 2 year life span.
Chum	Late Sept-late Dec.	Lower reaches of Lower Fraser tributaries.	Emerge in spring and move directly to estuaries where they may rear before migrating to sea (1-2 days).	2-3 years.
Steelhead trout (anadromous)	February to April	In tributaries and mainstem areas of streams in Lower Fraser.	1-2 years. Migrate as smolts to sea in spring.	4-5 years. After spawning many trout return to sea and some return to spawn again.
Cutthroat trout (anadromous and resident stocks)	February-May at 3-5 years	Small streams. Widely distributed throughout Lower Fraser.	1-5 years. Those that migrate ofter remain in estuary and move in and out with tides.	Varies.

A secondary measure utilized by the BC MWLAP is the age distribution of white sturgeon (*Acipenser transmontanus*), which is on the provincial Red List of threatened or endangered species. Three populations (Nechako, Kootenay, and Columbia) are listed as critical by the BC Conservation Data Centre. Sturgeon spawn in three rivers: the Columbia, the Fraser and the Sacramento, and are commonly found throughout the Fraser River and its main tributary, the Nechako. Pollutants tend to accumulate in these long-lived species, and they may be sensitive to the effects of pesticides being applied adjacent to their habitat.

Another measure used to assess environmental condition is the status of the kokanee (*Oncorhynchus nerka*) due its economic and ecological importance in southern BC, primarily the Okanagan Valley. These freshwater sockeye salmon are recreationally fished and are dominant plankton eaters. They are an important food source for other fish species such as rainbow trout, lake trout, bull trout, burbot, and sturgeon. Over the past 30 years kokanee populations have been decreasing, and although rainbow trout populations appear to be stable at the moment, they are expected to decline as their food source, the kokanee, declines (BC MAFF 2001).

Lastly, the status of the bull trout (*Salvelinus confluentus*) is used as an environmental indicator. It is currently Blue Listed in British Columbia as vulnerable and has been designated as a species of special concern in Alberta. Bull trout populations have been extirpated in the majority of the rivers found in the United States, with the exception of the Klamath and Columbia Rivers which host limited populations. Bull trout are listed as threatened under the *US Endangered Species Act*, June 1998.

Marine and freshwater algae and phytoplankton are also exposed to pesticides, and may be sensitive to impacts associated with herbicides. As a source of habitat and food for a multitude of organisms, phytoplankton plays an important role in the ecology of both marine and fresh water species. A decrease in their availability to consumers may in turn affect keystone species such as freshwater salmon and invertebrates. Little information is available on effects of pesticides on this food chain mechanism.

Invertebrates comprise a wide range of phyla, and may be affected by pesticides. Their pesticide tolerance will vary greatly depending on the species and feeding mechanism but bioconcentration and bioaccumulation is well documented in species such as crabs, and bivalves especially in highly contaminated waters such as estuaries and slow moving water (Johnson and Davis 1996; Kerr and Vass 1973; Yunker and Cretney 1995).

Groundfish species which commonly inhabit inshore areas, such as rockfish, lingcod, and flounder (i.e. starry flounder (*Platichthys stellatus*)), or which inhabit inshore areas during rearing stages, may also be exposed to pesticides as they enter the marine environment (Johnson 1973). Most groundfish rely on bottom sediments for camouflage, breeding, spawning and as a food source (by scavenging sediments for detritus). When groundfish are exposed to contaminated sediments, the absorption of pesticides through their gills or skin is facilitated (Custer 1996).

The life stage of biota at the time of exposure plays a significant role in dictating whether a toxic effect will occur. One case study indicated that the anti-sapstain didecyl dimethyl ammonium chloride (DDAC) was more toxic to some life stages of species than others. DDAC was found to be highly toxic to early life stages of sturgeon (40-60 days), though less so to some other fish, such as starry flounder which is found in the same parts of the Fraser estuary. DDAC was also found to readily adhere to particles and is therefore deposited quickly in sediment, raising concern about possible effects on groundfish.

1.4 PESTICIDE CLASSES

Prior to the discussion of pesticide use in the Pacific Region, we will present a brief overview of the characteristics of the main "types" or "classes" of pesticides that are currently on the market. The term pesticide applies to all products that are designed to manage, destroy, attract or repel pests. They include herbicides, insecticides, and fungicides, as well as, algicides, insect and animal repellents, antimicrobial and cleaning products, wood and material preservatives, and insect and rodent traps. For the purposes of this report, we will focus on insecticides, fungicides and herbicides used in the forestry and agricultural industries, and in urban areas. In all, there are just over 40 pesticide classes or groups registered for use in Canada (http://www.hc-sc.gc.ca/pmra-arla/english/index-e.html). The most widely used pesticides, excluding microbials, belong to four classes: organochlorine, organophosphate, carbamate, and triazines and these will be discussed in further detail below. There are also numerous products now available on the market that are thought to have no long term residual effects, such as the pyrethroid and biological classes.

1.4.1 Organochlorines (OCs)

Historically, OCs have been the most widely used insecticide class; they were used extensively during the mid 1940s to the mid 1960s. OCs are characteristically hydrophobic or lipophilic making them insoluble in water and highly bioaccumulative in biota. Due to their low water solubility, high volatility and long half-life, OCs tend to persist in the environment and are easily transported by wind currents, river systems (via particle binding) and ocean currents. Various OCs have been detected in snow pack and glacial melt in pristine areas of the Arctic where no OCs have been used.

Globally, OCs have been detected in marine biota such as eggs of the ancient marbled murrelet (*Synthliboramphus antiqus*) (Elliott *et al.* 1989; Addison and Ross 2001; Muir *et al.* 2000; Muir *et al.* 1996; Tanabe and Tatsukawa 1991) and various marine mammals. Although most OC organochlorine pesticides were either deregistered, cancelled, suspended or restricted in the 1970s in North America, they are still being detected around the world. In fact lindane and endosulfan are still used in BC today. Residues where OC pesticides have been used in the past are transported to the marine environment primarily by runoff. In developing countries where some of these products are still in use, OCs can volatize and move great distances through atmospheric processes where they then condense and precipitate out in colder regions such as the mountainous and cold northern regions.

Among the effects caused by OC exposure in vertebrates is the suppression of the immune system, damage to major organs such as the liver, reproductive and developmental impairment, infertility, birth defects and cancer. Rainbow trout have experienced delayed mortality (death 28 days after exposure) and changes in growth and behaviour at extremely low doses (Leblond *et al.* 2001; Little *et al.* 1990).

1.4.2 Organophosphates (OPs)

Since the ban of most OCs in the 1970s, the use of OPs and carbamates has increased dramatically (Mineau, P. *eds.* 1991). Their use has increased, in part, as a result of the shorter half-lives of new products which require more product to achieve the same desired effect that OC pesticides once produced. OP compounds have become the most widely used group of insecticides in the world and are used primarily in agricultural and residential applications (PAN -UK 1996). However, although OPs tend not to persist in the environment, they have a high acute toxicity, especially to non-target organisms (Mineau, P. *eds.* 1991; PAN -UK 1996). Birds appear to be particularly vulnerable most likely due to the direct eating of granular products which are mixed with agricultural seed; and the subsequent poisoning of scavengers like eagles (Glaser 2001; Elliott *et al.* 2000; Elliott and Norstrom 1998; Elliott *et al.* 1996a; Elliott *et al.* 1996b; Elliott *et al.* 1989; Elliott and Harris 2001; Kannan *et al.* 1998; Pearce *et al.* 1989; Vermeer *et al.* 1993).

OPs act by the inhibition of AchE enzyme activity which ultimately leads to respiratory paralysis and death (Glaser 2001). Specific compounds associated with wildlife mortality between 1980-1993 in the United States include chlorpyrifos, diazinon, dicrotophos, dimethoate, disulfoton, famphur, fenamiphos, fensulfothion, fenthion and fonofos (Glaser 2001). Laboratory studies on the sublethal effects of diazinon have also been documented in atlantic and chinook salmon in Canada (Scholz *et al.* 2000; Moore and Waring 1996). The OPs azinphos-methyl, chlorpyrifos, diazinon, disulfoton, fonofos, malathion, methyl parathion, and terbufos were found in the surface waters of California's Central Valley between, 1992-1995 indicating that these pesticides, can enter the aquatic environment (Dubrovsky *et al.* 1998). Health Canada's Pest Management Regulatory Agency (PMRA) is currently reviewing all OP pesticides used in Canada. Updates on OP re-evaluations are available on the PMRA website http://www.hc-sc.gc.ca/pmra-arla/english/pubs/pubs-e.html.

1.4.3 Carbamates

Carbamates are also fast-acting on their targeted "pest," but tend to persist longer in the environment than OPs. They are generally non-bioaccumulative, but are acutely toxic to insects, animals and humans. Carbamate compounds include aldicarb, aminocarb, carbaryl, carbofuran and methiocarb. Four carbamate pesticides have been related to wildlife mortalities in the United States: carbofuran, methiocarb, oxamyl, and aldicarb (Glaser 2001). The carbamates aldicarb, carbaryl, carbofuran and methomyl were also found to occur in the surface waters of California's Central Valley in the San Joaquin-Tulare basins (Dubrovsky *et al.* 1998; Kuivila and Foe 1995; Kuivila 1999). All of the carbamates except for aldicarb were sold or used in BC in 1999 (ENKON Environmental Limited 2001). Aldicarb is no longer registered for use in BC.

1.4.4 Triazines

Triazines are moderately persistent in the environment and are relatively insoluble in water, with half-lives measured in months. These herbicides act by inhibiting photosynthesis in problematic plants and include the herbicides atrazine, simazine, and propazine. Triazines are widely used globally and are popular among corn growers. Atrazine, in particular, is a well-known triazine and has been detected in both surface and ground water samples in Puget Sound. The exposure of atlantic salmon smolts to atrazine during downstream migration may subsequently effect growth and contribute to mortality of the smolts once they enter the sea (Fairchild *et al.* 2002). Triazines are a major concern because of their high soil mobility.

> ***Numerous pesticide classes are currently on the market in British Columbia and the Yukon. Organochlorines were commonly used in North America until many were banned in the 1980s. However, the legacy of past activities continues as organochlorine pesticides are generally persistent. Currently, organophosphates are the most widely used of the pesticide classes. Despite their relatively rapid breakdown in the environment, much remains unknown about the impact of sporadic pulses in sensitive ecosystems, the nature of their breakdown products, and their fate. In BC and the Yukon, salmonids may be particularily vulnerable during certain lifestages, given their dependence on habitat that spans freshwater to marine and may run through forestry, agriculture and/or urban waterways.***

1.5 "INERT" INGREDIENTS IN PESTICIDE FORMULATIONS

The active ingredient in pesticide formulations is what is intentionally used to control or kill target organisms. However, other ingredients are also added to the active ingredient such as surfactants, dyes, catalysts, and intensifiers to augment the effects of the active ingredient or facilitate their dispersion. These ingredients are often termed "inert" and can account for up to 99% of a product's ingredients. Adjuvants, surfactant blends et cetera that are mixed with pesticides by the user during application are not deemed an "inert ingredient" (Cox 1999); therefore, they will not be discussed in this report, as are added to the primary active ingredient by the user and not the manufacturer. However, future consideration should be given to assess the potential risk that these products may have on aquatic biota.

Pesticide manufacturers are required to label products with the quantity of active ingredient present in their products but not the inert ingredients used in the product formulation. Inert ingredients are not readily disclosed and are withheld as they are considered a trade secret (Northwest Coalition for Alternatives to Pesticides (NCAP) 1998; Marquardt *et al.* 1998).

So why are inerts of concern? Several cases have been reported where the inert ingredients used were in fact more harmful than the active ingredient, or where the inert ingredients have enhanced the toxicity of the active ingredient (Northwest Coalition for Alternatives to Pesticides (NCAP) 1998; Marquardt *et al.* 1998). A case study on Roundup®, a commercial pesticide which contains glyphosate, was conducted in 1987. The active ingredient was found to be less toxic to salmon than the surfactant used in the formulation, (MON 0818)(Wan *et al.* 1987). However, glyphosate by itself is considered to have relatively low toxicity (Cox 1998; Anton *et al.* 1994; Wan *et al.* 1989). A study in 1991 found that the triphenylmethane dye (Basacid Blue NB755), used in both aerial and ground applications of Roundup® (glyphosate), 2,4-D, 2,4-DE, and Garlon 4® (triclopyr), was toxic to salmonids, especially in naturally soft water (Wan *et al.* 1991). The use of Basacid Blue in conjunction with 2,4-D, 2,4-DE, and Garlon 4® (triclopyr) was also found to increase the toxicity of these formulations to young salmon (Wan *et al.* 1991).

According to the US EPA, 50 inert ingredients of significant toxicological concern (Table 3) have been identified as carcinogenic, reproductive toxicants, neurotoxic, or developmentally toxic (birth defects) in laboratory or human studies (United States Environmental Protection Agency 2001).

The US EPA has further identified approximately 60 inert ingredients that are believed to be toxic and should be further assessed (Table 3). These inert ingredients are structurally similar to chemicals known be toxic, and some have data suggesting a basis for concern about the toxicity of the chemical. Most of the chemicals on this list have been designated for testing through the National Toxicology Program (NTP), the EPA Office of Toxic Substances (OTS), or other regulatory or government bodies in the US.

The PMRA evaluates ingredients such as solvents, emulsifiers, colourants and fragrances that are found in pesticides. These inert ingredients are reviewed to assess risks to human health and the environment. In Canada, pesticides containing an inert ingredient which is recognized as being of toxicological concern (i.e. appears on the US EPA List 1), must be removed from the product or its safe use supported with detailed tests that examine the potential risks posed to human health and the environment. According the new pesticide legislation, the *Pesticide Control Products Act*, inert identified as being of toxicological concern must now be identified on the product label.

> ***"Inert ingredients" are generally not required by Canadian or US laws to be listed on pesticide product labels. Therefore, the extent to which the inert ingredients listed in Table 3 are sold/used in the Pacific Region is unknown. If the US EPA's estimate that inert ingredients comprise an average of 32% of a pesticide formulation by weight (Marquardt et al. 1998) is correct, we can estimate that approximately 2.5 million kilograms of such unknown substances are applied in the BC/Yukon environment each year. This figure could be higher or lower depending on the product(s) in question and the type of land use activity utilizing pesticide products.***

Table 3: "Inert ingredients" identified by the US EPA as a toxicological concern (United States Environmental Protection Agency 2001). Canada has adopted this list and utilizes it in the screening and registration of pesticides.

Inerts of toxicology concern		Potentially toxic inerts high priority for testing	
CAS No.	Chemical Name	CAS No.	Chemical Name
62-53-3	Aniline	85-68-7	Butyl benzy phthalate
1332-21-4	Asbestos fiber	84-74-2	Dibutyl phthalate
71-43-2	Benzene	84-66-2	Diethyl phthalate
1332-21-9	1,4-Benzenediol	131-11-3	Dimethyl phthalate
3068-88-0	B-Butyrolacetone	117-84-0	Dioctyl phthalate
7440-43-0	Cadmium compounds	95-49-6	2-Chlorotoluene
75-15-0	Carbon disulfide	1319-77-3	Cresols
56-23-5	Carbon tetrachloride	95-48-7	o-Cresol
108-90-7	Chlorobenzene	106-44-5	p-Cresol
67-66-3	Chloroform	108-39-4	m-Cresol
62-73-7	DDVP	108-94-1	Cyclohexanone
106-46-7	p-Dichlorobenzene	95-50-1	o-Dichlorobenzene
117-87-7	Di-ethylhexylphthalate (DEHP)	112-34-5	Diethylene glycol monobutyl ether (butyl carbitol)
54-14-7	1,1-Dimethyl hydrazine	111-90-0	Diethylene glycol mono ethyl ether (carbitol)
540-73-8	1,2-Dimethyl hydrazine	111-77-3	Diethylene glycol mono methyl ether (methyl carbitol)
534-52-1	Dinitro-o-cresol	34590-94-8	Dipropylene glycol monomethyl ether
51-26-5	Dinitrophenol	111-76-2	2-Butoxy-l-ethanol (ethylene glycol mono butyl ether)
123-91-1	Dioxane	5131-86-8	1-Butoxy-2-propanol (1,2-propylene glycollmono butyl ether
106-89-8	Epichlorohydrin	124-16-3	1-Butoxyethoxy-2-propanol
110-80-5	Ethanol, 2-ethoxy (cellulosive)	107-98-2	1-Methoxy-2-propanol
111-15-9	Ethanol ethoxy acetate	29387-86-8	Propylene glycol monobutyl ether
96-45-7	Ethylene thiourea	25498-49-1	Tripropylene glycol monomethyl ether
107-06-2	Ethylene dichloride	577-11-7	Dioctyl sodium sulfosuccinate
109-86-4	Ethylene glycol monomethyl ether; methyl cellulosive	141-79-7	Mesityl oxide
140-88-5	Ethyl acrylate	106-10-1	Methyl isobutyl ketone
77-83-8	Ethyl methyl glycidate	75-52-5	Nitromethane
50-00-0	Formaldehyde	108-88-3	Toluene
70-30-4	Hexachlorophene	29395-43-1	Tolyl triazole
110-54-3	n-Hexane	95-14-7	1,2,3-Benzotriazole
302-01-2	Hydrazine	120-32-1	2-Benzyl-4-chlorophenol
78-59-1	Isophorone	7500-3	Chloroethane
7439-92-1	Lead Compounds	88-04-0	p-Chloro-m-xylenol
568-64-2	Malachite Green	97-23-4	Dichlorophene
1191-80-6	Mercury oleate	68-12-2	Dimethyl Formanide
591-78-6	Methyl n-butyl ketone	100-41-4	Ethyl benzene
74-87-3	Methyl chloride	149-30-4	Mercaptobenzothiazole
75-09-2	Methylene chloride	74-83-9	Methyl bromide
79-46-9	2-Nitropropane	75-43-4	Dichloromonofluoromethane
25154-52-3	Nonylphenol	75-45-6	Chlorodifluoromethane
30525-89-4	Paraformaldehyde	75-37-6	1,1-Difluoroethane
87-86-5	Pentachlorophenol	75-68-3	1-Chloro-1,1-difluoroethane
127-18-4	Perlcoroethylene (PERC)	25168-06-3	Isopropyl phenols. Petroleum hydrocarbons
108-95-2	Phenol	1330-20-7	Xylene
90-43-7	o-Phenylphenol	100-02-7	p-Nitrophenol
78-87-5	Propylene dichloride (1,2-dichloropropane)	106-88-7	Butylene oxide
75-56-9	Propylene oxide	79-24-3	Nitroethane
8003-34-5	Pyrethrins and pyrethroids	75-05-8	Acetonitrile
81-88-9	Rhodamine B	96-48-0	gamma-Butyrolacetone
10588-01-9	Sodium dichromate	71-55-6	1,1,1-Trichloroethane
131-52-2	Sodium pentacholorohenate	102-71-6	Triethanolamine
62-56-6	Thiourea	111-42-2	Diethanolamine
26471-62-5	Toluene diisocyanate	97-88-1	Butyl methacrylate
79-00-5	1,1,2-Trichloroethane	80-62-6	Methyl methacrylate. Xylene-range aromatic solvents
56-35-9	Tributyl tin oxide	95-82-9	Dichloroaniline
79-01-6	Trichloroethylene	95-76-1	Dichloroaniline
1330-78-5	Tri-orthocresylphosphate (TOCP)	626-43-7	Dichloroaniline
78-30-8	Tri-orthocresylphosphate (TOCP)	554-00-7	Dichloroaniline
		608-27-5	Dichloroaniline
		608-31-1	Dichloroaniline
		101-84-8	Diphenyl ether
		76-13-1	Trichlorotrifluoroethane
		75-69-4	Trichlorofluoroethane
		75-71-8	Dichlorotetrafluoromethane
		79-14-2	Dichlorotetrafluoroethane

1.6 PESTICIDE IMPURITIES AND CONTAMINANTS

Yet another concern are the numerous impurities and contaminants that may be found in many of the commonly used pesticide products on the market today. According to an article published by the Globe and Mail in November 10, 2003, federal regulators detected traces of dioxin and furans in 10 pesticides currently used in Canada. Impurities were found in 2,4-D products as well as in the wood preservative PCP. Dacthal, an agricultural herbicide, was found to contain dioxin levels 4,000 times higher than that permitted in drinking water standards in Ontario (Mittelstaedt 2003). Although dioxin and furans are not intentionally added to the pesticide, they are often a byproduct from some manufacturing processes. Other pesticides found to contain dioxin included dichlorophenoxyl-phenol, dicamba, 2,4-DP, hexaconazole, MCPA, mecoprop, and quintozene (Mittelstaedt 2003). Additional impurities have also been detected in both malathion (xylene) (Brenner 1992) and chlorpyrifos (0,0,0'0' tetraethyl dithiopyrophosphate) (AAL Reference Laboratories 1997).

1.7 METABOLITES AND BREAKDOWN PRODUCTS

As per "inert ingredients," limited information is readily available on the breakdown products of many of the currently used pesticides. However, it is known that some metabolites and breakdown products may be more toxic than their parent compounds. Metam sodium and dazomet are two pesticides which are considered to be relatively non-toxic, however, they both breakdown into methyl isothiocyanate (MITC) which is both highly toxic to fish and persistent in the environment (United States Environmental Protection Agency 2003). Alkylphenol ethoxylates, non-ionic surfactants that are used in some pesticide formulations, also breakdown into compounds that are more toxic than the parent compound. A possible breakdown product, nonylphenol, has an acute toxicity (LC50) of 17-3000 ppm in fish, with chronic toxicity values of 6 ppm (Bennis 1999; Maguire 1999; Servos 1999), and is a serious issue with regards to endocrine disruption. Unlike, the OC products once used, the majority of modern pesticides are designed to act, transform and degrade quite quickly. Unless we are aware of at least one transformation product and have the appropriate analytical methodologies to detect it, it will not be possible to determine the full presence/significance of possible problematic pesticides. Large quantities of pesticides are used each year in BC and the uncertainty of their breakdown properties warrants extreme concern to Fisheries and Oceans Canada.

1.8 INFORMATION SOURCES

Pesticides are classified according to use by provincial or territorial jurisdiction. An overview of the *Pest Control Products (PCP) Act* and regulations can be obtained from the PMRA website http://www.hc-sc.gc.ca/pmra-arla/english/index-e.html. We obtained information from three general sources including, i) domestic records, ii) forestry records, and iii) agricultural records. In determining what regulation applies to specific pesticides under the *PCP Act*, the classification of the pesticide must first be considered. Pesticides are listed in one of the following classes (BC MWLAP 2003b):

Permit-Restricted – These are the most strictly controlled substances and require a permit to be used or purchased. Permits are obtained through the BC MWLAP. Note: only one permit-restricted active ingredient, Abirtol® (4-aminopyridine) has been permitted for use over the past ten years by the province.

Restricted – Pesticides that require an applicator certificate in order to purchase or use; these products bear a restricted label. An applicators certificate is issued by BC MWLAP following the completion and passing of an applicator's exam.

Commercial – The majority of pesticides have a commercial label. These are intended for professional and commercial uses, and include landscape, agriculture and forestry applications.

Domestic – Those that are intended for use by non-professionals, in or around homes and gardens.

Exempted – These are exempted from many regulatory requirements. Most have "domestic" on the label and some have "commercial". They include disinfectants, swimming pool chemicals, insecticidal soaps, and insect repellents.

"Reportable" pesticides in BC are products that have a Restricted, Commercial, or Permit-Restricted use label. These include some, but not all, pesticides used for agricultural and industrial applications, as well as pesticides used on public lands. The reporting of pesticide use on private lands is not required, with the exception of private land use for forestry, transportation, public utility or pipe lines. This is one, of many, data gaps in determining total pesticide use in the Pacific Region.

Out of province sales represent an additional challenge, since products purchased within BC may be applied else where (i.e. Alberta), and products purchased in other provinces may be used in BC. This generally applies to regions along provincial boundaries such as Dawson Creek in northeastern BC along the Alberta border. Domestic sales are very difficult to determine as retail venders such as hardware stores, home and garden centers, and garden stores may purchase vast amounts of a given product from one location and then distribute it across the country to other outlets. Sales records to vendors are not required by wholesalers and may therefore not be accurate. Although retail outlets are required to record pesticide sales of reportable pesticides, there is no requirement to submit such records on an annual basis to BC MWLAP. Records of annual sales from retail outlets may be obtained by request through the Ministry but requires contact with each domestic pesticide vendor and is a time consuming task.

1.8.1 Domestic Records

One of the limitations of providing an accurate account of pesticide use in the Pacific Region was our inability to quantify domestic use, since vendors are not required to submit annual records of domestic sales. This represents a significant data gap, since pesticide loadings to the aquatic environment from urban areas are likely to be considerable. The Enkon Environmental Limited (2001) report, which was prepared for and funded by both Environment Canada and BC MWLAP, is to our knowledge, the only report that assessed domestic pesticide use for the Lower Mainland (i.e. Vancouver) and greater Victoria areas. Domestic use was assessed for this report by telephone surveys by members of the Georgia Strait Alliance (GSA) in the Greater Victoria area. A similar survey is projected for 2003 by BC MWLAP pending available funds (Linda Gilkeson, personal communications 2003). The Enkon 2001 report represents the third report conducted by Environment Canada and BC MWLAP (formerly BC Ministry of Environment Lands and Parks), thereby providing a temporal setting for such data. All told, these reports provide an overview of BC reportable pesticide sales and use for 1991, 1995 and 1999.

Over the past several years PMRA has committed itself to gathering provincial pesticide sales data to generate a national overview of pesticide sales and is currently developing reporting requirements for sales. Further information is available on the Federal/Provincial/Territorial (FPT) committee website http://www.hc-sc.gc.ca/pmra-arla/english/fpt/fpt-e.html.

Similar surveys were also conducted in the Yukon in 1986 and 1995 (Hall *et al.* 1995; White 1986). These surveys differ greatly and are not comparable. However, these reports provide an overview of the basic types of pesticides used and sold in the Yukon at that point in time.

1.8.2 Forestry Records

Unfortunately, pesticide use surveys for both BC (19991, 1995, and 1999) and the Yukon (1986 and 1995) did not examine pesticide use by the forestry sector. Information regarding the pest control products used by the forestry industry (standing crops) in BC was obtained through the National Forestry Database Program (Canadian Council of Forest Ministers 2002). However the data set lacks completeness. The majority of the active ingredients listed both herbicides and insecticides, was ambiguous, and quantities used during the past two to three years were not available. For these and other reasons, amounts and rates were not readily comparable with regards to determining temporal trends in usage or in active ingredients used. No figures were available for the Yukon Territory.

Data on pesticide permits issued were obtained through BC MWLAP for the years 1990 to 2002 for different provincial regions. Data were compiled for pesticide applications during the period 1990 - 2001. These records reflect permits issued by the province for forestry application and include the amount of active ingredient (kg) and method of application. Information is archived in an internal database system known as CRISP (Comprehensive Record and Information System on Pesticides). It should be noted that permitted use may not reflect the actual amount used. Also, in some cases where more than one application method was used (i.e. both aerial and ground applications) the permit was entered into the database as a single application method (i.e. aerial) however, the actual amount used is accurately reflected. Other problematic issues include quality assurance and quality control and null entries for the past three years due to logistical problems with the Ministry during this time period.

Information regarding wood preservative and anti-sapstain use in BC, provided by Enkon's 2001 report, was obtained through surveys of individual wood treatment plants. Again, there is no central reporting system for wood preservative or anti-sapstain sales or use, with the exception of four plants located in the Greater Vancouver Regional District (GVRD) which report to the local municipality (ENKON Environmental Limited 2001).

1.8.3 Agricultural Records

Agricultural use of pesticides was assessed through numerous resources. The primary source was again, the Enkon 2001 report, which provided the quantity of pesticides sold and used in 1999. In order to quantify more recent use patterns, crop profiles were obtained from the BC MAFF. These profiles provided detailed information on pesticide application, rates, timing and total number of applications per year. The majority of the information was obtained through recent publications. However, in cases where information was not readily available, it was obtained through personal communications with the BC MAFF, Minor Pesticide Use Coordinator in Abbotsford.

Several databases on annual sales of reportable pesticides are maintained by different provincial regions. However, there are no central efforts by the province to collect or collate these regional databases. In addition, such regional efforts focus solely on sales, and do not differentiate between sales and use. To generate an accurate measure of current pesticides used, active ingredients of interest must first be identified and correlated to the region in which they are used by cross referencing with the latest sales figures (i.e. the Enkon 2001 report). Each region must then be queried by BC MWLAP staff for each of the active ingredients listed, representing a labour intensive activity. For obvious reasons, this was not conducted for this report.

Despite the widescale use of pesticides in forestry, agriculture, and domestic applications in BC/Yukon, information on the quantity of different pesticides used in different areas in the Pacific Region is not readily available. Geographical Information System (GIS)-based use information would be an asset in correlating land use activity with active and inert ingredients and sensitive fish habitat. A centralized reporting system and information warehouse for sales and use numbers for the Region merits serious consideration. This data gap makes it difficult to readily and accurately assess the actual quantities of pesticides used in BC/Yukon.

2.0 PESTICIDE USE IN THE PACIFIC REGION

Canada has more than 7,000 pesticides registered for use. The Crop Protection Institute of Canada reported that agricultural use of pesticides accounted for 91% of the total national pesticide sales in 1997 (Standing Committee on Environment and Sustainable Development 2000). Saskatchewan represented 36% of the total pesticide sales in 1997, followed by Alberta and British Columbia 24% (combined), Manitoba 18%, Ontario 16%, Quebec 4% and the Atlantic provinces 2% (Standing Committee on Environment and Sustainable Development 2000). The following sections review the results of past pesticide surveys conducted in the Pacific Region by land use activity.

2.1 BRITISH COLUMBIA

According to the Enkon 2001 report, BC sold or used 8,102,384 kg of pesticide active ingredients (excluding domestic label use, but including veterinary use for flea control) in 1999. This represents a 19% increase from 1991 figures. Of the total used in 1999, 87% were anti-microbial (wood preservatives and anti-sapstains), 5% were insecticides (including biologicals), 4% were herbicides, 3% were fungicides, and 1% were classified as "other" (including fumigants, plant growth regulators, insect growth regulators, molluscicides, vertebrate control products, adjuvants and surfactants).

Of the 286 active ingredients used or sold in BC in 1999, the top 20 used represented 95% of the total (Table 4) (ENKON Environmental Limited 2001). Among the 20 listed were creosote (66.5% of pesticides sold or used in BC), chromated copper arsenate (CCA) (11.4%) and didecyl dimethyl ammonium chloride (DDAC) (3.8%). These compounds are used in the forestry industry as wood preservatives or as anti-sapstains. Other pesticides used or sold in significant amounts included mineral oil (3.2%, insecticide or adjuvant), PCP (2.5%, wood preservative), borax (1.8%, also used as a wood preservative), and glyphosate (1.3%, isopropylamine form). Not only have these chemicals been in high use but their use has also significantly increased from 1991 (Table 4) with the exception of PCP, DDAC, mineral oil (herbicidal or plant growth regulator), captan, IPBC and metiram which have either decrease or stayed relatively consistent between 1991 and 1999.

Interestingly, of the 286 active ingredients used in BC in 1999, 166 ingredients showed an increase in use between 1991 and 1999. Significant increasing have been noted for creosote (wood preservative), chlorothalonil (fungicide used primarily by the agricultural sector and in urban landscaping/golf courses), formaldehyde (fungicide used in mushroom growing operations), and *Bacillus thuringiensis* species (bioinsecticide used by both forestry and agricultural sectors).

Table 4: Quantity of top 20 pesticide active ingredients sold or used in BC in 1991, 1995 and 1999 (excluding domestic pesticides) ((ENKON Environmental Limited 2001) – Appendix B and E).

Active Ingredients	1991 Sales (kg)	1995 Sales (kg)	1999 Sales (kg)	Percent Change in Sales from 1991 to 1999
Creosote	1,690,998	5,869,461	5,387,761	218.6
CCA	651,134	912,392	923,987	41.9
DDAC	371,518	455,954	310,046	-16.5
Mineral Oil (Insecticidal or Adjuvant)	162,245	206,440	261,845	61.4
PCP	789,110	122,966	201,642	-74.4
Borax, all forms	87,800	187,823	142,578	62.4
Glyphosate, Isopropylamine	110,157	124,698	108,763	unknown*
Mancozeb	29,511	41,907	44,682	51.4
Sulphur	28,101	26,319	36,393	29.5
Mineral Oil (Herbicidal or Plant Growth regulator)	38,540	25,215	35,260	-8.5
Metam	27,437	20,422	30,855	12.5
Captan	28,451	29,160	27,498	-3.4
Glyphosate Acid	n/a	n/a	26,810	unknown*
Chlorothalonil	3,721	15,871	26,640	615.9
IPBC	28,291	35,248	26,569	-6.1
Formaldehyde	3,007	14,342	25,495	747.9
Diazinon	19,643	22,552	24,563	25.1
Metiram	27,618	20,874	23,890	-13.5
Bacillus thuringiensis, Serotype H-14	3,188	11,270	21,875	586.2
Bacillus thuringiensis, Berliner spp. *Kurstaki*	3,095	12,283	17,895	478.2

Chromated copper arsenate (CCA), didecyl dimethyl ammonium chloride (DDAC), pentachlorophenol (PCP) and iodocarb (IPBC).

*Values for glyphosate acid were included in the values shown for glyphosate, isopropylamine for years 1991 and 1995 therefore percent change in sales from 1991 to 1999 were not able to be determined. However the overall change in sales for both forms of glyphosate was 23%.

N/A = not available.

In all, the greatest sales and use of pesticides is associated with wood preservatives, having almost doubled in use between 1991 and 1999 (Table 5). Reportable pesticide sales and use comprise the second largest amount, with a 19% increase since 1991. The sales and use of anti-sapstains decreased in use (43%), but still represents the third largest component. Agricultural pesticide sales increased (+106%) since 1991, while landscape services and flea control products decreased in use and sales by 40% and 78% respectively.

Table 5: Summary of pesticide sales or use in BC by category between 1991 and 1999 (ENKON Environmental Limited 2001).

Survey Category	1991 (kg)	1995 (kg)	1999 (kg)	Change from 1991 (kg)	Percent Change in Sales from 1991 to 1999
Wood Preservative Use	3,685,955	6,905,728	6,529,878	+2,843,923	77
Anti-Sapstain Chemical Use	838,319	754,314	479,251	-359,067	-43
Reportable Pesticide Sales	916,933	1,005,086	1,093,195	+176,262	19
Flea Control Product Sales	718	622	156	-562	-7.8
Use by Landscape Services	15,154	14,802	9,071	-6,083	-40
Use by Agricultural Services	42,083	No data	86,565	+44,482	105

Note: Forestry values were not included in pesticide use surveys in 1991-1999, and were therefore not available for analysis. Dramatic decrease in flea control product sales is a reflection of advancing flea control technology. The majority of the external flea control products have been replaced with medication that is administrated orally. Two major changes include the increase use of imidacloprid and the elimination of chlorpyrifos.

The use of pesticides in 1999 (in terms of hectares of land application) was evaluated on a regional basis in BC (Figure 21). The Peace region greatly surpassed other regions in terms of herbicides used based on area treated (Figure 23). However, the Peace region produces primarly forage crops which are perennial in nature and typically have a three year crop rotation. Herbicides, in particular, are heavily applied before planting to remove competitive weeds, however, once the crop is established, very little pesticides are applied as they would greatly effect the viability of the crop and profit margins. In contrast, the Lower Mainland and Southern Interior (Thompson-Okanagan) regions exhibited large use of all three pesticide classes (herbicides, insecticides and fungicides) and have a wide variety of agricultural and urban activities that result in a steady use of pesticides. It should be noted that the regional boundaries used in the 1999 survey were based on the 1991 regions, although the official boundaries have since changed (Figure 22) and are used in the CRISP database (records of permits issued).

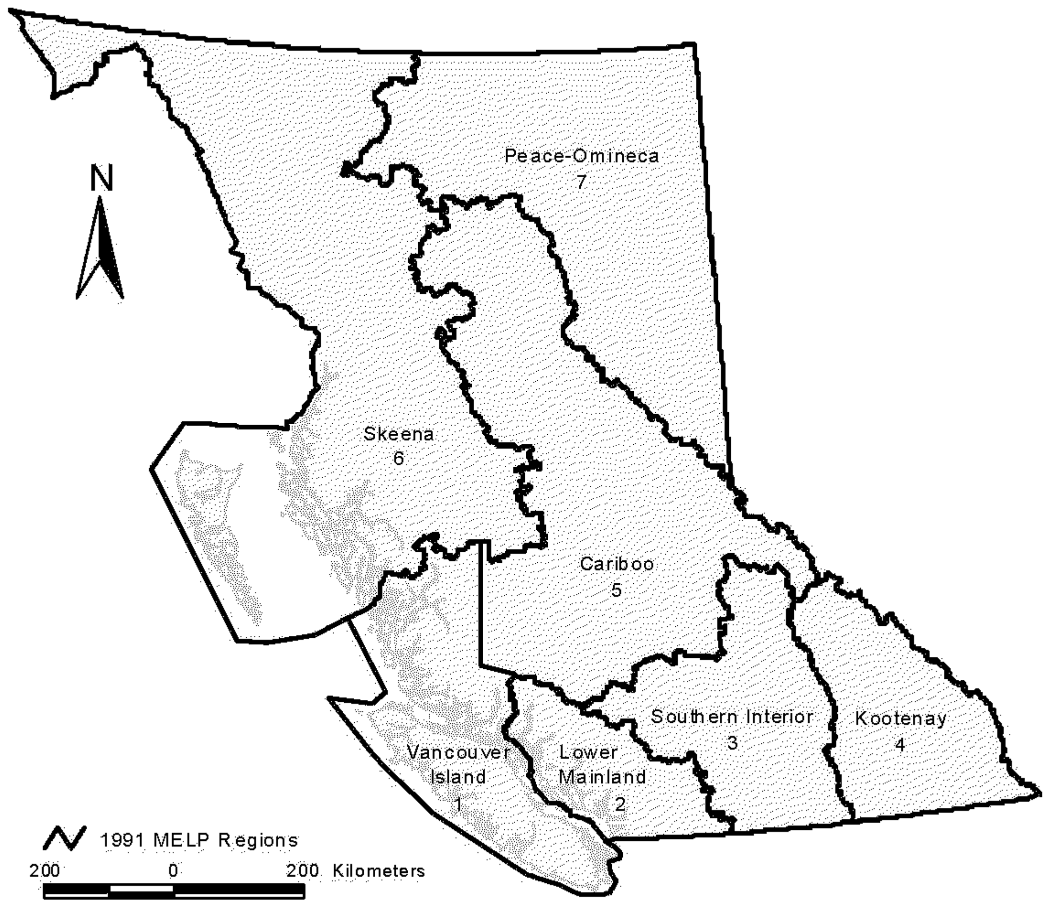


Figure 21: Map of the regions used for the 1999 pesticide sales survey (ENKON Environmental Limited 2001).

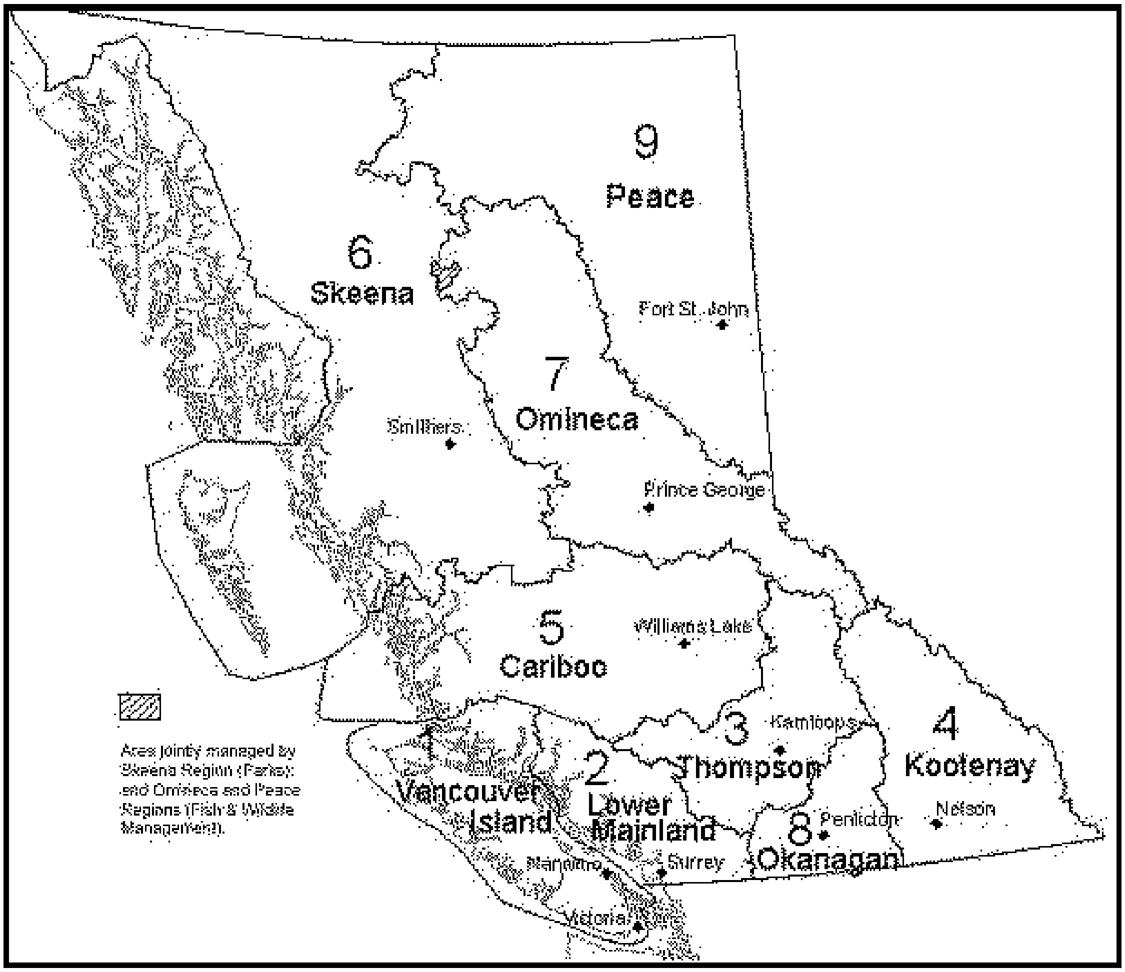


Figure 22: Ministry of Water, Land and Air Protection regions in 2003 (BC MWLAP 2003b).

Note: In the CRISP database which records permits issued by the province, regions 7 and 9 are designated as regions 7a and 7b, respectively. Regions 3 and 8 were formally unified and termed the Southern Interior (region 3) and are projected as such in the CRISP database.

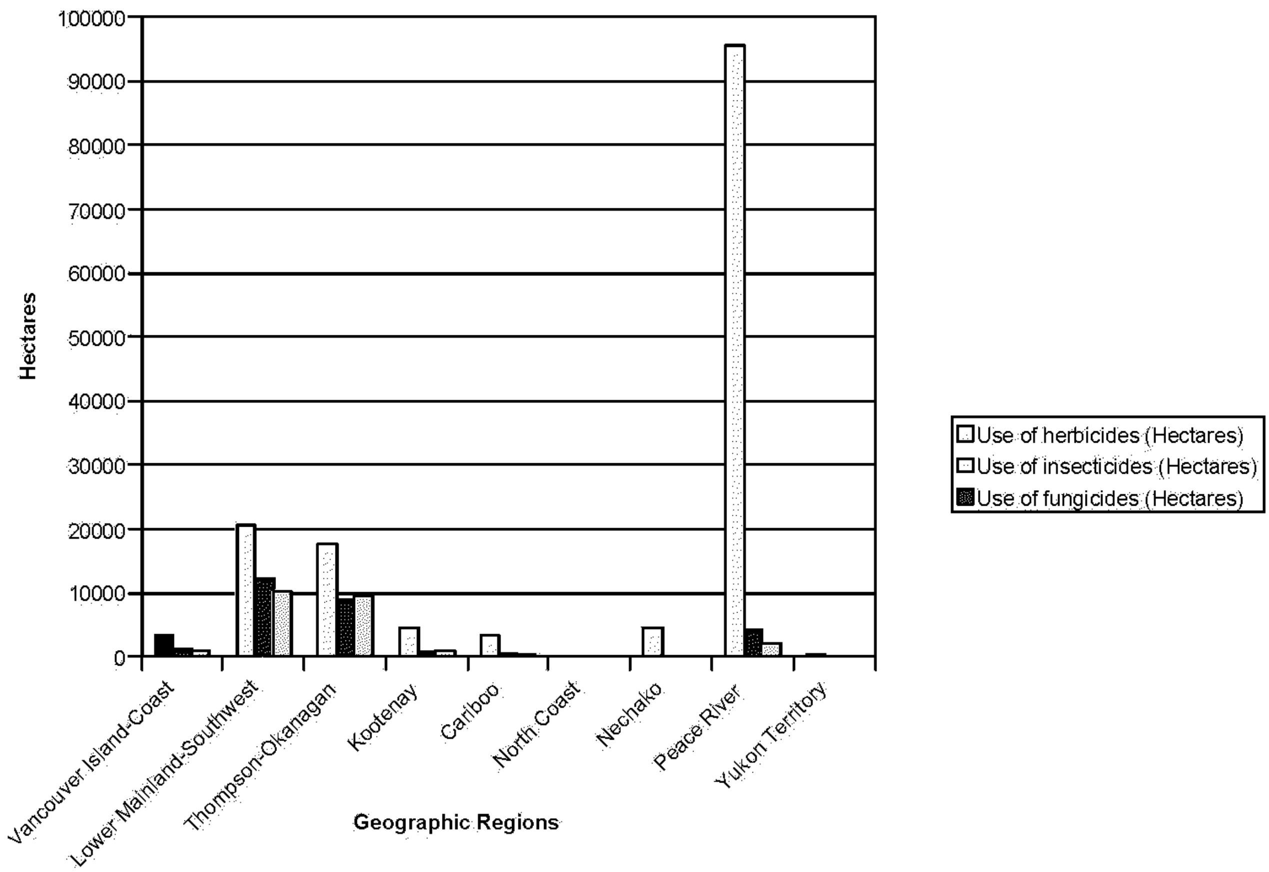


Figure 23: Pesticide use (ha) in BC by region, 1999. Data source: (ENKON Environmental Limited 2001).

2.1.1 Urban

In general, urban pesticide use nationally is on the rise, reflecting, in part, increasing population density. Although no estimates of urban sales or use is available in BC for our analysis, several studies have examined the issue of urban pesticide use and the products most readily used. Urban use, particularly from unlicensed individuals, is thought to be the highest contributor to runoff due to improper use, high application rates and quantities and growing population trends (United States Geological Survey 1992). Hundreds of pesticide products are available on the market for domestic use, but only about a dozen are commonly used. According to the Partnership for Pesticide Bylaws, a non-profit organization based in Toronto, 11 products comprise the majority of domestic use for lawn and garden purposes (2002). These include the herbicides 2,4-D, dicamba, mecoprop, MCPA (2-methyl-4-chlorophenoxyacetic acid), and glyphosate; the insecticides malathion and carbaryl; and the fungicides chlorothalonil, benomyl, quintozene and bendiocarb. Of the 11 active ingredients, nine were identified as being either highly toxic to fish, persistent, endocrine disrupting, or a cholinesterase inhibitor.

The remaining two, mecoprop and MCPA, were identified as having a potential for contaminating surface or ground waters.

Supporting evidence also indicates that insecticides such as diazinon, carbaryl, chlorpyrifos and malathion tend to occur more frequently, and are found at higher concentrations in urban streams compared to in agricultural streams (Stout 1986). Herbicides have also been found to be widespread in surface and ground waters. The same study found that the majority of streams associated with high herbicide levels are those located near lawns, golf courses, and road right-of-ways. The urban use of pesticides easily surpasses agricultural use in the Puget Sound Basin (Grant and Ross 2002 after Tetra Tech Incorporated 1988) of Washington State, further highlighting the concerns about urban pesticide use in the Pacific Region. This is likely most of concern in the lower Fraser River regions where sensitive salmon spawning grounds are located and urban densities are the greatest.

A telephone survey of Victoria residents was conducted by the Georgia Strait Alliance (GSA) in 1999 to quantify domestic pesticide use. 34% of respondents had used herbicides, insecticides and/or fungicides. 'Weed and Feed' combinations were amongst the most popular, these contained 2,4-D, dicamba and/or mecoprop amine. Other frequently used pesticides consisted of glyphosate isopropylamine, metaldehyde, insecticidal soap, diazinon, ferric phosphate, and a sulpur/zineb/methoxychlor/rotenone combinations (ENKON Environmental Limited 2001).

2.1.1.1 Landscaping Services

Another indicator of urban pesticide use is the amount used by landscaping services. In the Enkon 2001 report, rural pesticide use by landscaping services in the Lower Mainland region was found to have decreased by 40% (6083 kg) between 1991 and 1999. However, increased use of some pesticides by landscapers was evident. The largest increase in landscape use included insecticidal soaps (717 kg, up 227%), chlorothalonil (371 kg, up 1200%) and quintozene (326 kg, 70%). Products heavily used by landscapers which had decreased in use by 1000 kg included sodium metaborate tetrahydrate, sodium chlorate and glyphosate isopropylamine (45 to 96% decrease), as well as paraquat with a 600 kg decrease (97%) since 1991. Overall, mineral oils, insecticidal soaps, glyphosate isopropylamine and 2,4-D comprised 57% of the total pesticides used by landscapers (Figure 24).

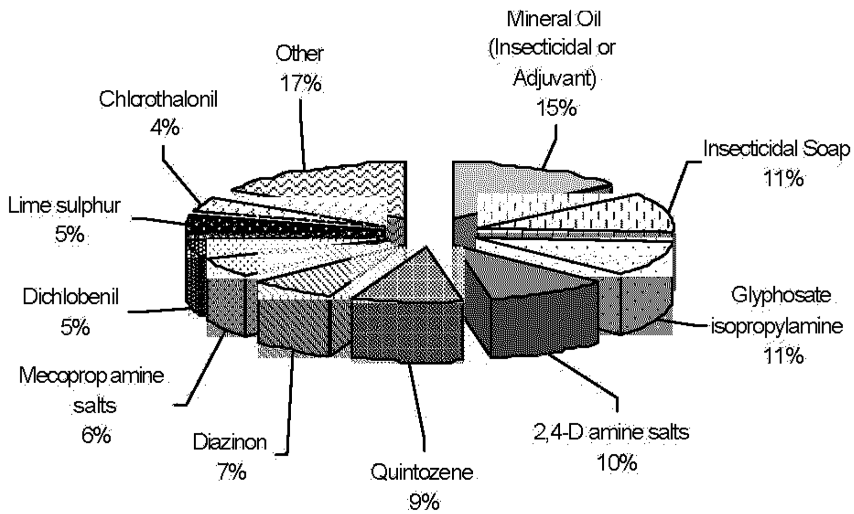


Figure 24: Percentage of pesticide active ingredients used by licensed landscape services in the Lower Mainland region, 1999 (ENKON Environmental Limited 2001).

Compared to the 1991 summary, five of the nine pesticides used by landscaping services in the Lower Mainland, that are listed by Environment Canada as priority substances of concern in the Georgia Basin, were no longer used in 1999 (BC MWLAP 2003e). These included malathion, lindane, trifluralin and endosulfan and octylphenoxypoly-ethoxyethanol. Since 1991, many landscapers have adopted Integrated Pest Management (IPM) plans, which include the use of less toxic products such as insecticidal soaps and mineral oils.

2.1.1.2 Golf Courses

There are currently 330 golf courses (private and public) in BC, the majority of which are in the Lower Mainland (101), Thompson/Okanagan (79, includes lower portion of Omineca region) and Vancouver Island (69, includes coastal portion of Central Coast region). The Kootenay region has 43 courses while the Cariboo has 16 and Northern BC (Peace, Skeena, and upper Cariboo regions) has 22. In comparison with other regions in Canada, British Columbian and Albertan golf courses have the fewest pest problems (especially those from disease and insects) and therefore uses less pesticides (less than 100 kg of active ingredient per golf course) (Alberta Environmental Protection 1998).

Golf courses use both preventative and curative treatments. Herbicides and fungicides are used more commonly than insecticides with herbicides applications used for two to three years consecutively, eliminating the majority of weed concerns. Fungicides are used on fungal pathogens which can cause severe grass loss. The most commonly used pesticides include the insecticides diazinon, chlorpyrifos and carbaryl; herbicides 2,4-D,

mecoprop and dicamba; and the fungicides quintozene, iprodione and chlorothalonil (Standing Committee on Environment and Sustainable Development 2000).
A study conducted in 1995 examined golf course practices in the Fraser River Basin (UMA Environmental 1996). Pesticides were detected in five out of 25 water and sediment samples collected. With the exception of dicamba and 2,4-D, recommended limits for pesticides in water or sediment were not available at the time of this report. Pesticides detected in both water and sediments included 2,4-D and dicamba, while iprodione and mecoprop were detected in water. Of those detected, 2,4-D exceeded the Canadian Water Quality Criteria in one water sample (UMA Environmental 1996). Iprodione was found at the highest concentration (0.013mg/L in a single water sample). An extensive list of pesticides commonly used on golf courses, their application, timing, form and toxicity is available (UMA Environmental 1996).

2.1.1.3 West Nile Virus

An emerging issue in BC is the expectance of West Nile virus. The virus has rapidly swept the United States and Canada; however, to date BC has not had any reported cases. Despite this, the province has issued a permit for the use of various larvicides and adulticides in the event that West Nile is detected (BC MWLAP 2003d). Larvacides are pesticides which are sprayed directly onto water bodies to eradicate mosquito larvae and may be subject to violation of the *Fisheries Act* 36(3) as a deposit of a deleterious substance into fish bearing waters. In Canada, there are five larvacides registered for mosquito control: *Bacillus thuringiensis israelensis* (Bti), methoprene, chlorpyrifos, malathion and dichlorvos. Adulticides, pesticides which are sprayed in the ambient environment to target adult mosquitos include malathion, propoxur, dichlorvos, resmethrin, pyrethrin, chlorpyrifos, methoxychlor, naled and -trans allethrin.

In BC, the permit issued for 2003/2004 for the control of mosquito species on public or private lands (including water bodies) permit the use of two larvacides, Bti (ground and aerial application) and methoprene (ground application only) and two adulticides, malathion (ground and aerial application) and synergized pyrethrins or synthetic pyrethroids (ground application only) (BC MWLAP 2003d). The permit does outline specific constraints such as no direct application of Bti to permanent fish bearing water bodies or waters which flow directly into fish bearing waters, flowing waters or waters containing fish, and the application of adulticides shall maintain a 10m pesticide-free zone along all waterbodies (BC MWLAP 2003d).

Although no pesticide applications have been made to date in BC for the treatment of West Nile virus, it is thought that the virus will reach BC within the next year and application will be necessary. Fortunately, many of the other provinces in Canada have already started treatment programs for West Nile, and BC has the opportunity to examine the results of such programs. Fisheries and Oceans Canada should be concerned with the application of these pesticides in proximity to and on fish bearing waters and therefore should be involved in the pesticide programs to be used in BC.

2.1.1.4 Industrial rights-of-way

Industrial use of pesticides in rights-of-ways also plays a significant role in the potential contamination of fish-bearing streams. In BC, industrial operations that use pesticides in areas of right-of-ways include, but are not limited to, electrical, railroad, and natural gas distribution companies. Such companies have Integrated Vegetation Management Plans in place.

BC Hydro, is the primary electrical company in BC, and uses pesticides for weed control in electrical facilities, vegetation management on rights-of-ways and the preservation of wood poles. According to reports, BC Hydro accounted for 0.51% of all pesticides used in BC in 1999 (both herbicides and wood preservatives) (Guite 2003). Electrical facilities are required to be kept weed-free for safety purposes. Pesticide use is limited and is not likely to pose a significant threat to fish or fish habitat. Preservation of wood poles is designed to extend the lifespan of utility poles; these are tested frequently for structural integrity. Approximately 75,000 poles are treated each year under permits issued by the province with a small number of poles treated under Service License Endorsements. Treatments of poles already in use are undertaken in the field with products that are either painted on or injected into the poles (these are subsequently plugged). Among the active ingredients more readily used are metam, creosote, copper naphthenate and boric acid (Guite 2003). The extent to which these products are leachable, and their proximity to fish-bearing streams is unknown, although the risk to the aquatic environment is expected to be minimal if application and clean-up procedures are adhered to.

The largest herbicide application by BC Hydro is for vegetation management in areas of rights-of-way. Transmission lines connecting generation facilities with urban centers run approximately 20,000 km with a total of 70,000 km of powerlines operating throughout the province. Herbicides are used on these rights-of-ways on deciduous trees that resprout after cutting. Again, permits for spraying are issued by the province with a small amount performed under Service License Endorsements. Triclopyr and glyphosate are the most commonly used active ingredients followed by diuron and simazine (Guite 2003). According to BC Hydro, herbicide applications are all target-specific and highly selective with only a very small proportion of the areas of rights-of-way treated each year. The use of pesticides in areas of rights-of-way are a possible concern to Fisheries and Oceans Canada, especially in areas of close proximity to waterways and in soils/terrain that promote leaching of pesticides into waterways (sandy/clay sediments, rock, steep terrain, etc.).

There are several railway companies that operate in the Pacific Region. Vegetation management is required by law to control weeds and other flora that hinder track safety, interfere with vehicle operations, present tripping hazard for workers, are a fire hazard or restrict visibility. Pesticide use is monitored by BC MWLAP through permits issued and is recorded in the CRISP database, but was not obtained for the purposes of this report. However, pesticides used by railway companies have been detected in nearby ditches which flow into salmon habitat, many at levels exceeding the LC50 (96-hr) values for salmonids (Wan 1994; Wan 1992; Wan and Oostdam 1995; Wan 1991). Among those detected were various dioxins and furans, polycyclic aromatic hydrocarbons (PAH's) and chlorophenols. BC Rail's wood preservatives are recorded by BC MWLAP.

Vegetation management is carried out using several methods for the various zones, the ballast zone (track area), and areas of rights-of-way (Table 6). A combination of mechanical methods and herbicides are used. In the 1980s, a bromacil/diuron formulation and tebuthiuron were widely used (Canadian Pacific Railway 2003). However, since the 1990s the pesticides most commonly used have been primarily glyphosate and to a lesser extent clopyralid, picloram, chlorsulfuron, bromacil, diuron and imazypyr (BC MWLAP 2003a). In 2001 the use of diuron, picloram and 2,4-D dominated with an increasing use of triclopyr (Canadian Pacific Railway 2003). Permits have been issued recently (2003) for glyphosate, chlorsulfuron, dicamba, imazapyr, diuron, and bromacil/diuron (BC MWLAP 2003c). According to BC Rail (2002), herbicide use over the past decade has fluctuated substantially, and has ranged from 2 kg in 1991 to 6,164 kg in 1999. Pesticides have also been used to preserve railway ties including creosote, copper naphthenate, and PCP. PCP has not been used in treating railway ties since 1995 (Canadian Pacific Railway 2003). According to a study conducted by the Swiss Federal Laboratories for Materials Testing and Research (EMPA), one-third of creosote applied as preservative to wooden railroad ties is emitted during the ties' normal service time (Schaefer 2000).

Train routes are used to transport goods and people through corridors, most of which are along waterways. Several companies, including Canadian Pacific and BC Rail have developed environmental sensitivity maps and databases illustrating known areas of environmental sensitivity along their routes and itemizing the precautions/procedures to be used when treating these areas with pesticides.

Table 6: The selection of herbicides used by BC Rail (Corporate Environmental Services BC Rail Ltd. 2002).

Zone	Target Vegetation	Active Ingredient
Ballast	All vegetation	Bromacil/Diuron mixture Diuron Imazapyr Chlorsulfuron Triclopyr Glyphosate Clopyralid
Right-of-way	Brush, broadleaf and conifers	Chlorsulfuron Picloram/2,4-D mixture Picloram Triclopyr Glyphosate Clopyralid
Yards, power and communication facilities	All vegetation	Bromacil/2,4-D mixture
All locations	Noxious weeds	Picloram Glyphosate Triclopyr Clopyralid

2.1.2 Forestry

Pesticide use by the forestry industry may be separated into two categories: that used on standing timber and that used on harvested timber as wood preservatives and anti-sapstains. The Enkon 2001 report did not include pesticide use by the forestry industry for standing timber and was therefore compiled from the National Forestry Database Program (NFDP) (National Forestry Database 2002) and through the CRISP database managed by BC MWLAP. The NFDP data summarized the total hectares applied, rates, and method of application from 1990 to 2001 (Appendix B). The CRISP database was able to provide us with use by region in terms of amount (kg) of active ingredient used and method of application (Appendix C).

2.1.2.1 Standing Timber

In the application of pesticides on private and publicly owned forest land, permits or pest management plan approvals are required from BC MWLAP. Five categories comprise the majority of permits issued including vegetation management, health protection, forestry rights-of-way, forest range and noxious weed control. Pesticide data for permits issued since 1990 were acquired through BC MWLAP, and were summarized for the period 1990-1999 (Table 7). The quantity of pesticides applied by year by region is indicated by permits issued (Figure 25). In general, vegetation management accounted for approximately 90-99% of pesticide permits used over a ten-year average with the exception of region 3 (Southern Interior), in which forest health protection represented 86% (Table 7). A detailed account of pesticide types, application method, area (ha), and region is provided in Appendix C. In 1993 and 1998 outbreaks of spruce budworm in the Southern Interior are thought to be responsible for the substantial increase in pesticide use.

Table 7: Percentage average of the quantity of pesticides permitted by sub-category by region from 1990 to 1999 (BC MWLAP 2003a).

Sub-Category	Region							
	Vancouver Island	Lower Mainland	Southern Interior	Kootenay	Cariboo	Skeena	Omineca	Peace
Forest Health Protection	3.4	0.1	86.1	0.3	0.1	4.7	4.6	1.7
Right-of-Way	7.5	0.3	0.8	0.0	0.0	0.3	0.3	0.2
Vegetation Management	89.1	99.6	8.9	89.1	99.2	91.7	91.2	97.1
Range Management	0.0	0.0	2.3	0.9	0.1	1.2	0.3	0.2
Noxious Weed Control General	0.0	0.1	1.9	9.8	0.7	2.1	3.8	0.8

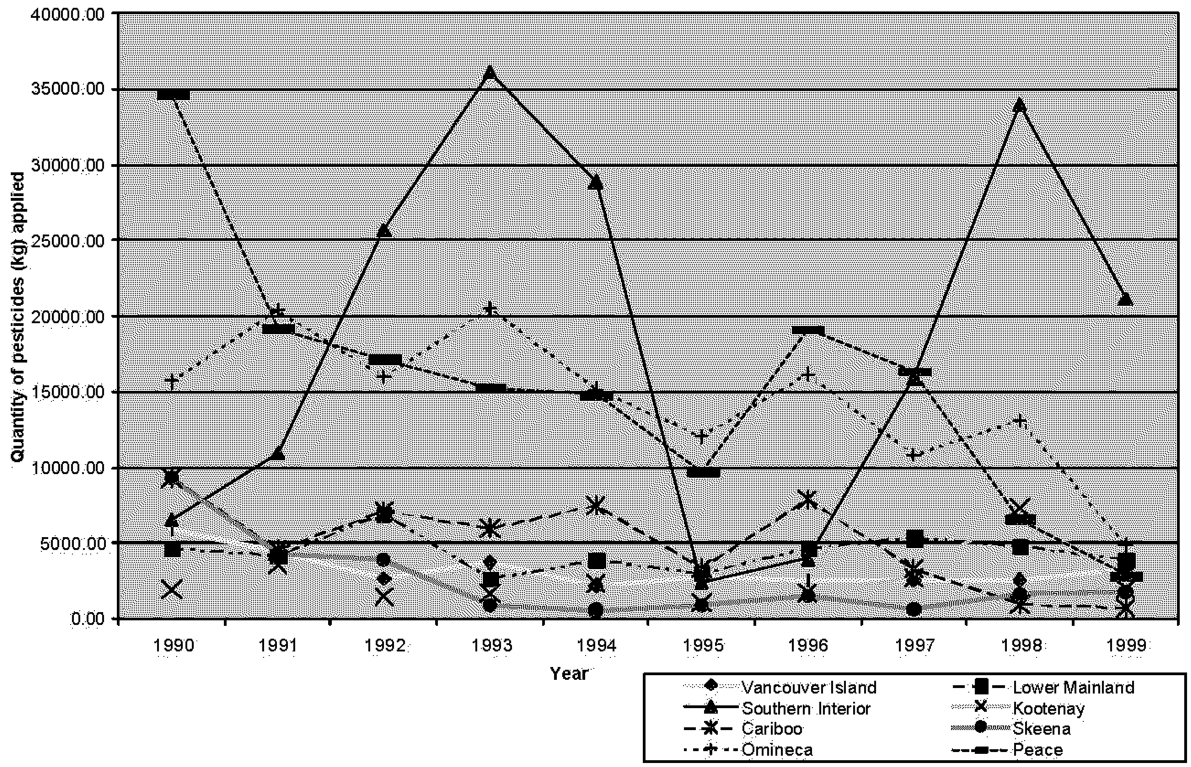


Figure 25: Quantity of all pesticides applied by the forestry sector between 1990-1999 according to permits issued by the BC Ministry of Water, Land and Air Protection (2003a).

2.1.2.1.1 Herbicides

Glyphosate represents the primary herbicide used by the forestry sector, and according to personal communications with various provincial departments, this herbicide accounts for approximately 90% of forest pesticide use (Appendices B and C). Glyphosate is applied to standing crops to prepare sites for planting or for releasing tree seedlings from brush competition and/or to reduce competitive broad leaf and herbaceous deciduous underbrush to facilitate sapling grow in and timber harvest. It is applied both aerially and by a ground-based treatment to selected areas. Increasing in use is the herbicide triclopyr, which is applied by ground treatment (basal bark treatment) since aerial application is not permitted in BC (Boateng 2003; Cronin 2003). Triclopyr is highly toxic to fish according to the manufacturer's label, and should be applied using buffer zones and other mitigative measures. The increasing use of triclopyr coincides with the increase in Fraser River late-run sockeye pre-spawning mortality (Johannessen and Ross 2002), raising concern about the possible involvement of this pesticide in the sockeye crisis. However, no direct evidence exists which provides a mechanistic basis for their observations, highlighting the need for future research on the endocrine disrupting effects of pesticides.

Other active herbicide ingredients used include picloram, and 2,4-D, although their use has been decreasing in recent years. Toxicity of these compounds vary with different formulations and application methods (Norris *et al.* 1983).

2.1.2.1.2 Insecticides

Bacillus thuringiensis Kurstaki (BtK) is the primary insecticide used by the forestry industry and has in recent years been used in conjunction with fenitrothion according to the NFDP (Appendices B and C). Other insecticide active ingredients include carbaryl, MSMA (monosodium methanearsonate) and the nuclear polyhedrosis virus. There has been significant controversy regarding the use of *Bacillus thuringiensis* (Bt) in general, although it appears to be relatively inert to most non-target organisms. The main concern with the spray application of Bt (both for mosquito and budworm control) is the surfactant that is used (i.e. "inert ingredients"); this information was not available to us.

A study on the effects of fenitrothion used to control a budworm outbreak on north Vancouver Island found that there was no direct correlation to a subsequent decrease in some insect orders that were seen. However, two other studies found that fenitrothion did affect behavioural traits of both juvenile Coho and young Atlantic salmon (Bull and McInerney 1974; Symons 1973).

Carbaryl is acutely toxic to fish at concentrations of 2 to 16 parts per million (ppm) (Sanders *et al.* 1983). Carbaryl bioconcentrates in fish tissues to levels much higher than those found in the surrounding water column. Lower concentrations may cause physiological, reproductive and behavioural effects (Zinkl *et al.* 1987; Cox 1993). Carbaryl breaks down into 1-napthol, which has been found to be even more toxic to a number of fish species (shiner perch, English sole, stickleback, goldfish, killifish and several freshwater species) than carbaryl itself (Cox 1993). Some carbaryl products are also known to contain petroleum hydrocarbons and crystalline silica. Sublethal concentrations of a commercial formulant caused more AchE inhibition in prawns than did the exposure to carbaryl alone, therefore reinforcing the toxicological effects of emulsifiers and other inert ingredients.

2.1.2.1.3 Fungicides

To our knowledge and no fungicides are used on standing timber.

2.1.2.2 Treated Timber

The runoff or leachate of pesticides from treated timber is primarily a concern in its end use, particularly when in or around fresh or marine aquatic environments. Due to the implementation of Best Management Practices, treatment facilities using wood preservatives and/or anti-sapstain chemicals have greatly reduced the amount of pesticides found in run-off from their facilities and have substantially decreased contaminant levels at discharging sites (Fraser River Action Plan 1998). In terms of environmental loadings, it is exceedingly difficult to quantify the amount of wood preservatives and anti-sapstains that may be reaching the receiving environment. Use data from treatment facilities indicate the total quantity of pesticides applied however, a substantial amount of treated timber is distributed worldwide and therefore does not accurately reflect the potential pesticide loadings to the region from which the product was treated.

In addition, many of the preservatives and anti-sapstains used, especially creosote and PCP, contain a substantial amount of chemical impurities. Despite manufacture's efforts to remove them, to what degree the manufacturers are successful no one knows (Wan 2003). Many of these products are used in electrical and telephone poles, railway ties and bridges, wooden wharfs and pontoons, and landscaping where the preservative/anti-sapstain are readily leachable into nearby waterways.

2.1.2.2.1 Wood Preservatives

Wood preservatives and anti-sapstain chemicals made up 86.5% of the total amount of pesticides sold or used in BC in 1999 (ENKON Environmental Limited 2001). Of the total pesticides sold or used in the province, PCP made up 2.5%, CCA made up 11.4%, and creosote made up 66.4%. These wood preservatives are intended to protect cut wood that will be exposed to environment (i.e. railway ties, patio decks) against fungi, insects and marine borers. The majority of wood preservation facilities use only CCA. However, the few plants that do use creosote apply enough that it exceeds the amount of CCA used (Table 8).

Table 8: Wood preservative use by Region in British Columbia in 1999 (ENKON Environmental Limited 2001).

Wood Preservatives	Region					Total (kg)
	Lower Mainland	Southern Interior	Kootenay	Cariboo	Skeena	
Creosote	1,159,098	3,673,177	-	555,486	-	5,387,761
CCA	360,730	43,261	223,168	171,636	125,192	923,987
PCP	55,603	-	108,691	37,349	-	201,642
ACZA	16,488	-	-	-	-	16,488
Total (kg)	1,591,920	3,716,438	331,858	764,470	125,192	6,529,878

Copper chromated arsenate (CCA), pentachlorophenol (PCP) and ammoniacal copper zinc arsenate (ACZA).

The Southern Interior region was the highest user of wood preservatives, particularly creosote. The Lower Mainland was the second highest user, with creosote being important, although other preservatives were also used. Skeena used the least amount of wood preservatives, using only CCA. The Kootenays and Cariboo regions used moderate amounts. There are no wood preservative facilities on Vancouver Island or in Peace-Omineca regions however, timber treated with these preservatives is used.

14 of the 19 wood preservative plants in BC are located in the Lower Mainland (Fraser River Action Plan 1998). Although emissions have decreased substantially over the years, these plants produced an estimated 30,000 cubic metric tonnes of emissions annually in 1998 (Fraser River Action Plan 1998). In the late 1980s and into the 1990s, wood preservatives, especially PCP were reviewed. As of December 1990, at the request of manufactures, the registration of all sapstain control uses of tetrachlorophenol and PCP in Canada was terminated and its use for specialty applications was voluntarily withdrawn (Agriculture Canada 1990). Specialty applications may include paints and stains, wood joinery products, industrial water treatment products, remedial groundline wood preservatives, oil field biocides and material preservatives. PCP is highly toxic to fish and is typically comprised of 90% PCP, 4.5% TCP and 3% other phenols with a dioxin concentration of <2 ppm (hexachlorodibenzo-*p*-dioxins), a micro contaminant of the PCP production. Since 1991, the use of PCP has decreased by more than 500,000 kg, however, it remains widely used today.

Creosote is a distillate of coal tar, and is a complex chemical mixture comprised of up to 80% polycyclic aromatic hydrocarbons (PAHs). Creosote treated timber is often used in railway ties, telephone poles, and marine pilings, where there is a high potential for leaching into waters inhabited by fish. Creosote has higher leachability in freshwater than marine, however, in both cases, the amount is said to be small (Hutton and Samis 2000; Goyette and Brooks 1998). In sensitive areas, such as estuaries where the water velocity is slow, alternate wood preservatives are recommended (Hutton and Samis 2000).

A study conducted in the Sooke Basin showed that under worst case conditions, significant PAH contamination is restricted to an area within 7.5 metres of a structure such as a marine piling (Goyette and Brooks 1998). The response of extensive infaunal community analysis and laboratory bioassays indicated that significant adverse biological effects can also be found within a distance of approximately 0.65 metres from the perimeter of the structure. Slight adverse effects were also observed to a distance of 2.0 metres in laboratory bioassays but not in the infaunal community (Goyette and Brooks 1998). Although little is understood about the acute and chronic affects of PAH exposure to non-benthic biota, given the extensive use of wood preservatives in both freshwater and marine environments, wood preservatives are a concern to Fisheries and Oceans Canada.

2.1.2.2.2 Anti-sapstains

Anti-sapstain chemicals are used by lumber mills to prevent fungal growth, and result in the staining of cut lumber. Treated lumber is intended for use in construction where it will be sealed, painted and stained to protect it from outside elements. The risk to the marine environment is therefore expected to be lower than that of wood preservatives except for the period during which the lumber is treated and stored prior to use. Until recently, treated wood was often left outdoors and exposed, generating a substantial amount of runoff. However, lumber mills now have covered areas to temporarily store treated lumber, as well as catchment basins, to prevent runoff from entering waterways including stormdrains (Fraser River Action Plan 1998). The most commonly used anti-sapstain province-wide in 1999 was DDAC (at 310,044 kg) followed by disodium octaborate tetrahydrate (at 115,254kg) (Table 9). The heaviest use of anti-sapstains was on Vancouver Island, followed by the Lower Mainland.

Table 9: Anti-sapstains used by provincial region in BC in 1999 (ENKON Environmental Limited 2001).

Active Ingredient	Region				Total Used (kg)
	Vancouver Island	Lower Mainland	Southern Interior	Skeena	
TCMTB	1,134	-	-	-	1,134
DDAC	174,427	114,023	3,757	17,837	310,044
Disodium Octaborate Tetrahydrate	45,005	48,551	5,537	16,161	115,254
Disodium Tetraborate Decahydrate	-	26,250	-	-	26,569
IPBC	16,938	9,297	-	334	26,569
Total (kg)	237,505	198,120	9,294	34,332	479,251

Note: Borax constituents include disodium octaborate tetrahydrate and disodium tetraborate decahydrate.
2- thiocyanomethylthio benzothiazole (TCMTB) and iodocarb (IPBC).

In all, the use of anti-sapstains has significantly decreased ($P<0.01$) since 1991 (ENKON Environmental Limited 2001). This is due to the decreased use of DDAC and IPBC, in addition to, azaconazole, TCMTB, and sodium carbonate (which ceased completely in 1998) (ENKON Environmental Limited 2001). The figures for wood preservative and anti-sapstain uses are considered as underestimates due to the failure of various plants and mills to respond to Enkon's survey in 1999. However, available information does provide us with some understanding as to pesticide use in this industry.

2.1.3 Agriculture

In quantifying pesticide use in the BC agricultural sector, a variety of data sources were available. First, the Enkon 2001 report provided a list of the top 20 active ingredients used by the Lower Mainland pest control services licensed in the agricultural category for 1991 and 1999. Of those listed, eight have shown an increase in use. Of those, four are on the nominating toxic substance list identified by Environment Canada (Table 13a and b) including atrazine, metolachlor, nonylphenoxypolyethoxyethanol and surfactant blends. In addition, the use of pesticides by the agricultural industry has doubled between 1991 and 1999, from 42,083 kg to 86,565 kg respectively (Table 5) (ENKON Environmental Limited 2001).

To determine which active ingredients are used by farmers, crop profiles were obtained from the BC Ministry of Aquaculture, Food and Fisheries (BC MAFF). However, these profiles were available only for berry and tree fruit crops at the time of writing this report. Draft profiles were in various stages of completion for selected vegetable crops and were therefore not available for our review. In order to utilize the draft profiles without citing precise figures, information was obtained through personal communications with the Minor Use Pesticide Coordinator for BC MAFF, and ranked according to total percentage of crop (area) treated (e.g. 95% of all raspberry farmers use captan). Crop profiles are in fact a reflection of actual surveys of farmers by staff and are verified information. From the information provided, we were then able to identify products (and their active ingredients) predominantly used in the agricultural industry (Table 10).

Crops chosen for this analysis were those totalling more than 200 ha, and were based on figures from the Census of Agriculture for 2001 (BC MAFF 2002). Complete profiles are available in Appendix D.

Crops such as potatoes, cranberries and ginseng have been identified as a concern due to their proximity to water and/or heavy pesticide application (Nener and Wernick 1998a). Potato crops in BC are prone to outbreaks of wireworm which requires heavy pesticide use. Cranberries are grown in bogs which generally flood seasonally, allowing pesticide residues to migrate into the water. Most cranberry crops are grown in the Southern Interior and the Fraser River Valley. High concentrations of diazinon have been detected in irrigation ditches and tributaries downstream of cranberry bogs (both water and sediment samples) for up to 66 days after secondary treatments (Szeto *et al.* 1990). A study of chemigation, the injection of an insecticide into a sprinkler irrigation system, used in cranberry bogs has reported that azinphosmethyl run-off was found to be toxic to non-target resident fish when released into the aquatic environment outside the bogs (Wan *et al.* 1995; Szeto *et al.* 1990).

In the lower Fraser Valley (interior Fraser Basin in the Thompson Okanagan area), ginseng crops typically take five years to mature to harvest. Pesticide use is substantial (Nener and Wernick 1998a). Ginseng crops are grown on large plots adjacent to water ways. Due to heavy canopy cover associated with ginseng the number of pesticide application methods is limited and spray drift issues are not generally of a high concern however, the leaching of pesticides into adjacent waterways is.

Table 10: Summary of pesticide active ingredients, associated with high to very high application intensities (% area treated, as identified in Appendix D).

Crop Type	Fungicides	Insecticides	Herbicides
Berries (blueberries, cranberries, currants, gooseberries, raspberries, strawberries, and grapes) *Primarily in southern Vancouver Island and the Southern Interior*	Captan Copper Fenhexamid Iprodione Metalaxyl-M Triforine	Azinophos-methyl Diazinon	2,4-D Dichlobenil Glyphosate Mineral Oil Napropamide Oxyflurofen Simazine
Tree Fruits (apples, cherries, pears, and peach) *Primarily in the Southern Interior*	Copper Iprodione Myclobutanil Sulphur, lime sulphur	Azinophos-methyl BT Carbaryl Diazinon Dormant oil Imidacloprid	Glyphosate Paraquat
Vegetable Crops (beans, carrots, broccoli, cauliflower, brussel sprouts, cabbage, sweet corn, lettuce, green peas, and potatoes) *Primarily the Southern Interior and the Lower Mainland*	Captan Chlorothalonil Cymoxalin Mancozeb Metalaxyl-M Thiram	Acetmapiprid Chlorpyrifos Cyhalothrin-lambda Cypermethrin Deltamethrin Dimethoate	Bentazon Diquat Linuron Trifluralin
Forage Crops (cereals, corn, grasses and legumes for forage and seed, dry peas/lentils, and canola and rapeseed) *Primarily the Peace-Omineca and Cariboo*	Chlorothalonil Elemental sulphur	Carbaryl Chlorpyrifos Cyhalothrin-lambda Deltamethrin Methamidophos Methomyl Pirimicarb	2,4-D Atrazine Bentazon Bromoxynil Clodinafop-propargyl Clopyralid Cloquintocet-mexyl Cyanazine Dicamba Ethalfluralin Fenoxaprop-p-ethyl Fluazifop-p-butyl Fluroxypryr Fipronil Glufosinate ammonium Glyphosate Imazamethabenz Imazamox Imazethapyr Linuron MCPA amine, ester, and salts Metsulfuron methyl Metolachlor Nicosulfuron Pendimethalin Quinclorac Quizalofop-ethyl R-enantiomer Sethoxydim S-metolachlor Tralkoxydim Tribenuron methyl Thifensulfuron methyl

One of the main crop types for which profiles were not available were field/forage crops (i.e. pulse crops including cereals, canola and rapeseed, flax, corn, grasses and legumes for forage and seed, and dry peas and lentils). In order to quantify those pesticides most associated with these crops, several weed and crop protection specialists with BC MAFF were contacted, in addition to three custom applicators in the Peace River region (Dawson Creek and Fort St. John). These individuals were able to identify which products were most widely used or sold based on their expertise in the forage industry. Herbicides are more extensively used on forage crops than insecticides or fungicides, as very few pests or diseases affect BC forage crops (Clark 2003; Cranston 2003). Forage crops are perennial in nature; herbicides are therefore generally used during the first year of planting until the crop is established. Herbicide use during subsequent years is minimal, since heavy use may affect the crop yield (with the exception of pesticide resistant crops). In addition, slim profit margins limit expenditures on pesticides unless warranted (Clark 2003; Cranston 2003; Agrocore United 2003; Agrocore 2003). Herbicides are generally used in large quantities every 3 - 5 years and used minimally during the growing season.

2.2 YUKON TERRITORY

2.2.1 *Urban*

The first vendor pesticide survey conducted in the Yukon was in 1986. A total of 62 active ingredients were used in 328 different formulations in the Yukon Territory (White 1986). House and garden bug killers and mosquito coils were the most commonly sold products while creosote, 2,4-D and *Bacillus thuringiensis* (Bt) were used in the largest quantities (White 1986).

A similar study in 1994 by Amisk Technical Services, found that 85 active ingredients were used in over 300 different formulations (Hall *et al.* 1995). In this study, widely *used* insecticides included Bt and malathion; glyphosate was the primary herbicide; and creosote the most widely used wood preservative. In terms of amounts *sold*, creosote was the highest followed by the herbicides 2,4-D, mecoprop, glyphosate, and dicamba. The predominant insecticides sold included diazinon, chlorpyrifos, borax, allethrin, and pyrethrins. Wood preservatives, zinc naphthenate and copper naphthenate, were also widely sold. See Appendix A for actual figures.

In the 1994 survey, landscapers and municipalities apparently reported increased pressure from the public to reduce and/or cease the use of pesticides on public grounds such as parks and schools. A municipality in the Yukon ceased the use of malathion in 1991 and glyphosate in 1992 (Hall *et al.* 1995; Government of Yukon Canada 2003).

2.2.2 *Forestry*

Pesticides do not appear to be used in the forestry industry in the Yukon National Forestry Database Program (2002), although lack of reporting may reflect data collection and /or lax reporting requirements.

2.2.3 *Agriculture*

Information on agricultural pesticide use in the Yukon is available from the Environmental Protection & Assessment Division of the Yukon Department of the Environment (Government of Yukon Department of Environment 2003).

Due to the cold climate of the Yukon Territory and its limited agriculture, only small amounts of pesticide are used within the Territory. The largest single use of pesticides is for the control of mosquitos and biting flies (Hall *et al.* 1995). Historically, DDT was used (1950 to 1970). This was followed by fenthion, temephos, and malathion (1966 to 1970). Today *Bacillus spp.*, temephos, malathion, and propoxur are used for mosquito control (Hall *et al.* 1995).

The 2001 Census of Agriculture reported terrestrial pesticide application (Table 11). However, where less than three farms reported inputs, information was suppressed for confidentiality reasons and is represented by an "x". Fertilizers represented the largest land input and the application of herbicides represented the primary pesticide used.

Table 11: Yukon Territory land inputs (Hill *et al.* 2002).

Land Input Type	Number of farms reporting	Acres
Commercial Fertilizer	55	3,976
Herbicides	11	632
Insecticides	2	x
Fungicides	1	x

90% of all insecticides and 56% of all herbicides used in BC are applied in the lower Fraser Valley, highlighting concerns about the health of salmon and their habitat. In 1991, agriculture accounted for 13.7% of all pesticide use in the province, but this rose to 71% when wood preservatives and anti-sapstains, were excluded. Forestry accounted for 1.6% of total use, rising to 8% when wood preservatives and anti-sapstains were excluded. Urban and domestic pesticide applications accounted for approximately 4% of total use when wood preservatives and anti-sapstains were excluded. Unfortunately, no comparable data was available during subsequent surveys conducted in 1995 and 1999, impairing any ability to construct or interpret temporal trends in the province or its regions. Nonetheless, all three land use activities are of concern. The potential for pesticides to enter the freshwater/marine environment and adversely affect fish habitat or fish health represents a real, yet unquantified risk.

2.3 INTEGRATED PEST MANAGEMENT PROGRAMS

As a result of increased public awareness, pesticide use has become a controversial topic, especially with regards to its use in public areas such as parks, schoolyards and boulevards. Both federal and provincial governments promote the use of Integrated Pest Management (IPM), and host information on IPM techniques on their websites. Agricultural programs are in place and monitoring of farms practicing IPM techniques was conducted in 1998 (MacDonald 2003). Results suggest that berry farms in the Fraser Valley practice IPM techniques covering 77% of the total crop area. Similarly, vegetable farms practicing IPM techiques accounted for 85% of the total vegetable crop area. In the Peace River area, 95% of forage crop growers use IPM techniques. Orchard growers in the Thompson/Okanagan with IPM programs cover 78% of the crop area.

In urban areas, many municipalities (i.e. Victoria, Nanaimo, Port Moody, Shuswap, West Vancouver) are in the process of developing IPM policies to encourage the reduction of the cosmetic use of pesticides. Educational campaigns have been developed to bring information to residents on the use and effects of pesticides. Due to increasing awareness of IPM, one might expect to see a decrease in pesticide use. However, this has not been the case in most sectors (with the exception of landscape use).

2.4 POTENTIAL HOT SPOTS IN THE PACIFIC REGION

In determining potential "hot spots" of concern to Fisheries and Oceans Canada several factors must be considered. Population density can serve as an indicator of high urban use of pesticides (cosmetic, landscape). Intensive agricultural areas are of concern, although numerous factors must be considered, including active ingredients used, toxicity, persistence, soil types, and proximity to salmon bearing streams/rivers. With regard to forestry application, regions of high pesticide use, application method and active ingredient used, and proximity to salmon-bearing systems must be examined. Pesticides in snow and glacial melt are generally those used historically, such as DDT, that are either legacies from past use or have been transported through atmospheric process from other countries (near and far). In our report, we focus on current use pesticides, but possible effects from pesticides no longer in use in BC/Yukon represent an overlying concern.

> ***Available evidence suggests that the Fraser River Valley represents a critical area of concern for several reasons: i) high urban density, ii) intensive agricultural practices, iii) heavy use of pesticides in the forestry sector, particularly in the Thompson region, and iv) critical salmon habitat found throughout the Fraser River watershed with signs of a decreasing population trend in late-run sockeye salmon stocks.***

2.5 PESTICIDES OF CONCERN

Approximately 7000 pesticide products are registered for use in Canada, approximately 286 active ingredients were "used or sold" in BC in 1999. For the purposes of this report, we attempted to tabulate data and related information based on six lists that have identified pesticides as a concern based on a various criteria such as detection rates, endrocrine disrupting and bioaccumulative potential, environmental persistence, and sales trends (quantity in brackets specifies number of pesticides):

1- PMRA-Fisheries and Oceans Canada priority pesticide list (18).
2- Georgia Basin Ecosystem Initiative-Environment Canada priority pesticide list (24).
3- World Wildlife Fund-Pesticide Action Network Europe endocrine disrupting chemical list (105).
4- Environment Canada and BC MWLAP top 20 pesticides list.
5- Fisheries and Oceans Canada priority pesticide list (killer whales; 16).
6- Fisheries and Oceans Canada priority pesticide list (late-run sockeye; 32).

Properties of concern when considering risks to aquatic and other biota may include persistence in the environment, lipophilicity, and endocrine disrupting potential. These characteristics, coupled with the quantities used and trends, form the basis for our report. However, very little information on transport, fate and effects in the natural environment exists for many of these pesticides, highlighting the need for further research in different eco-regions and a degree of extrapolation from laboratory settings.

2.5.1 List 1 - PMRA-Fisheries and Oceans Canada priority pesticide list.

At the beginning of April 2003 The Pest Management Regulatory Agency of Health Canada identified a total of eighteen pesticides to Fisheries and Oceans Canada as being of national concern. The overall trends of most of the pesticides identified have decreased over the decade with the exception of seven: diazinon, chlorothalonil, glyphosate acid (in Table 12 not shown in Figure 26) and pendimenthalin, and to a lesser degree imidacloprid (not shown in figure but is shown in Table 12), sulfosulfuron, and chlorpyrifos (Figure 26).

Table 12: PMRA 18 pesticides of concernlist, comprising quantities of pesticides sold in BC in 1991, 1995 and 1999.

Active Ingredients	Quantity of Reportable Sales (kg)			Percent of All Total Reportable Sales (%)			Percent Change in Sales from 1991 to 1999 (%)
	1991	1995	1999	1991	1995	1999	
Chlorpyrifos	4,436	5,552	4,466	0.48	0.55	0.41	0.67
Diazinon	19,643	22,552	24,563	2.14	2.24	2.25	25.0
Malathion	12,094	6,523	6,691	1.32	0.65	0.61	-44.7
Imidacloprid	0	0	188	0	0	0.02	100.0
Endosulfan	6,857	7,308	4,712	0.75	0.73	0.43	-31.3
Methoprene	105	0.65	27.1	0.01	0.0001	0.002	-74.2
Atrazine	22,898	10,928	9,991	2.50	1.09	0.91	-56.4
Triallate	20,584	5,958	3,289	2.24	0.59	0.30	-84.0
Trifluralin	5,857	4,125	2,347	0.64	0.41	0.21	-59.9
Ethalfluralin	26,917	5,033	2,289	2.94	0.50	0.21	-91.5
Pendimethalin	333	1,119	2,422	0.04	0.11	0.22	627.3
Glyphosate Acid	0	0	26,810	0	0	2.45	100.0
Glyphosate , Isopropylamine	110,157	124,698	108,763	12.01	12.41	9.95	-1.3
Sulfosulfuron	0	0	96.4	0	0	0.01	100.0
Azoxystrobin*	0	0	0	0	0	0	0
Pyraclostrobin	0	0	0	0	0	0	0
Kresoxim-methyl	0	0	0	0	00	0	0
Chlorothalonil	3,721	15,871	26,640	0.41	1.58	2.44	615.9
Total	233,602	209,668	223,295	25.48	20.86	20.43	-4.41
Total Quantity of ALL Reportable Pesticides by Year	916,933	1,005,086	1,093,195				19.2

* In 1999 0.01kg of azoxystrobin was used by Pest Control Services licensed under the Agricultural category but was not classified as a reportable sale and therefore not included in the table. Sales figures obtained from (ENKON Environmental Limited 2001).

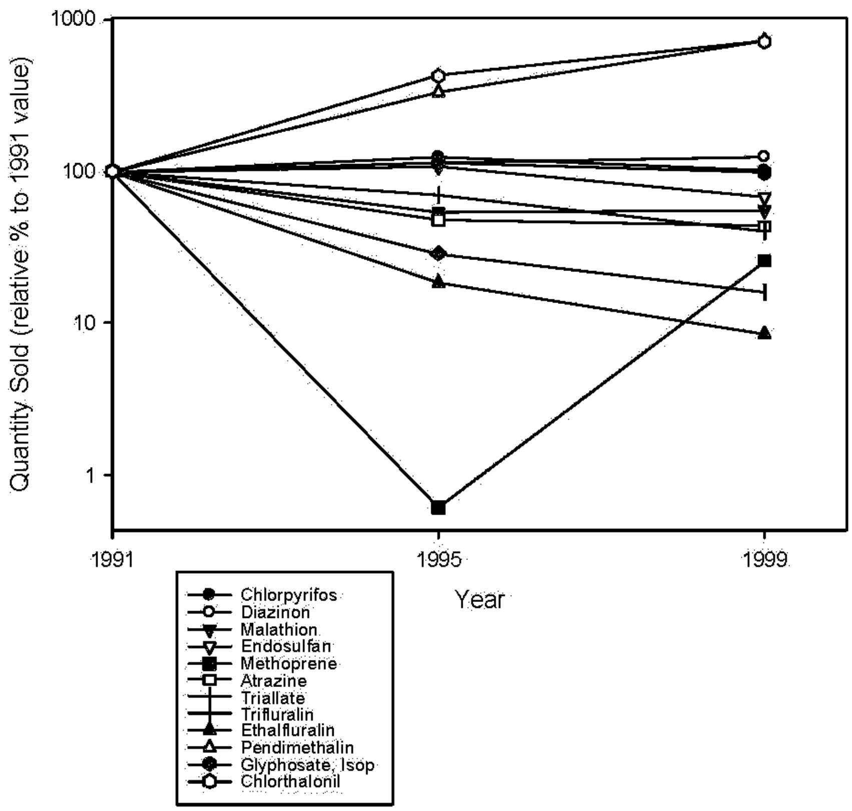


Figure 26: Sale trends of PMRA pesticides in BC.

Total sales of reportable pesticides of concern in BC in 1999 by region (Figures 27 a-h and 27 i-o) illustrates that diazinon, chlorothalonil, glyphosate (isopropylamine), atrazine, endosulfan, methoprene, pendimethalin, malathion, chlorpyrifos, trifluralin, and imidacloprid were predominantly sold in the Lower Mainland and the Southern Interior of BC. Glyphosate (acid), triallate, ethalfluralin and sulfosulfon were primarily sold in the Peace-Omineca region. However, the pesticides of concern identified by PMRA, with the exception of diazinon, chlorothalonil and glyphosate (isopropylamine), do not represent a large portion of the pesticide sales in BC (Table 12). It must also be noted that pesticides purchased in a region may not have been used or applied within the same region. In addition, the amount purchased in a given year may not accurately reflect the application rate or amount used in the same year. For example, 1000 kg of a given pesticide purchased in 1999 by a consumer may be used over a period of several years at various application rates. In this case, in documenting sales over an extended period of time, one may be able to determine buying trends within a region in general terms, but data will not accurately reflect application rates.

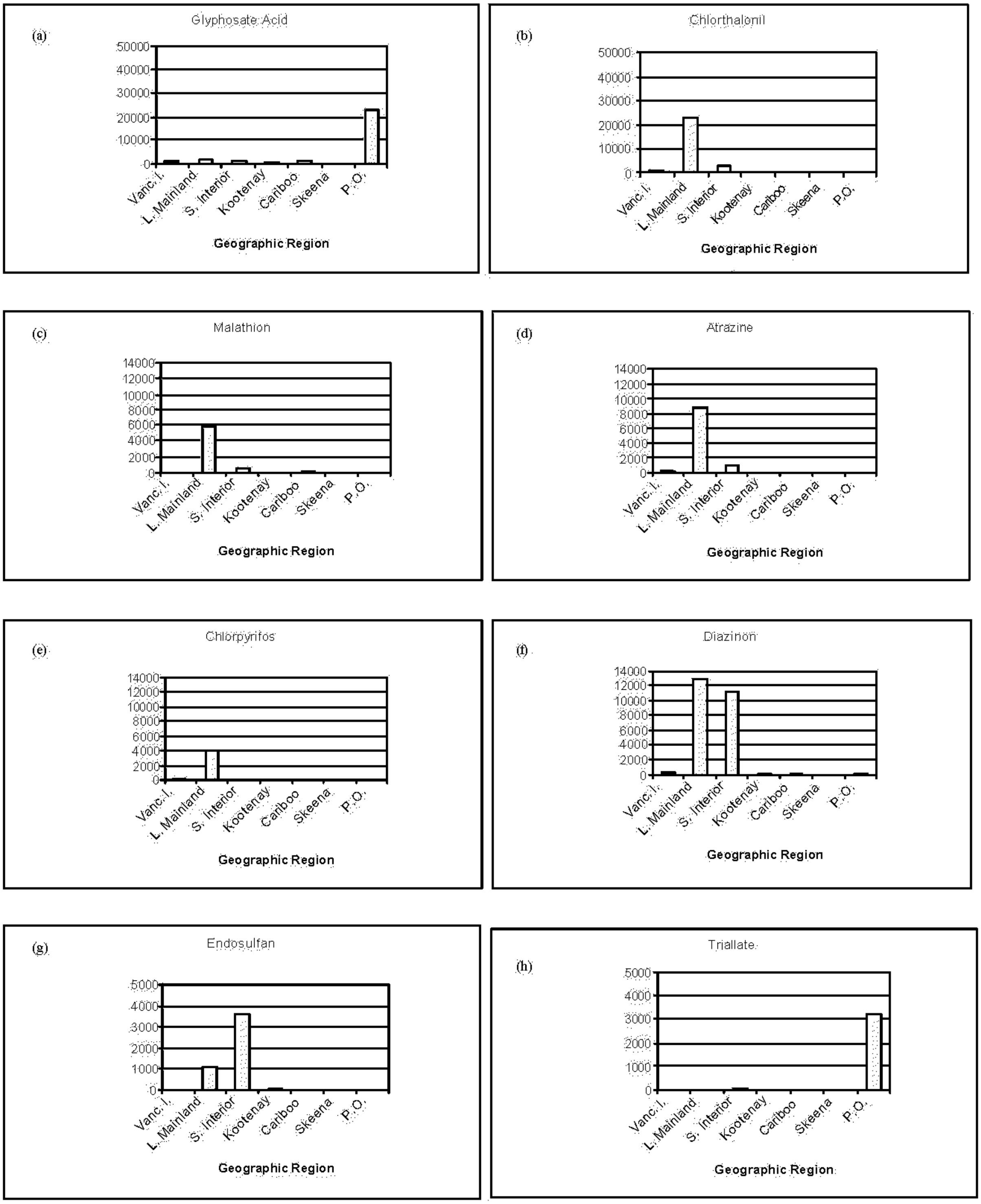


Figure 27 (a-h): Quantity (kg) of reportable pesticides of concern (PMRA shortlist) sold in BC in 1999 by region (ENKON Environmental Limited 2001). Data for Figures 27 (a-o) is available in Appendix E.

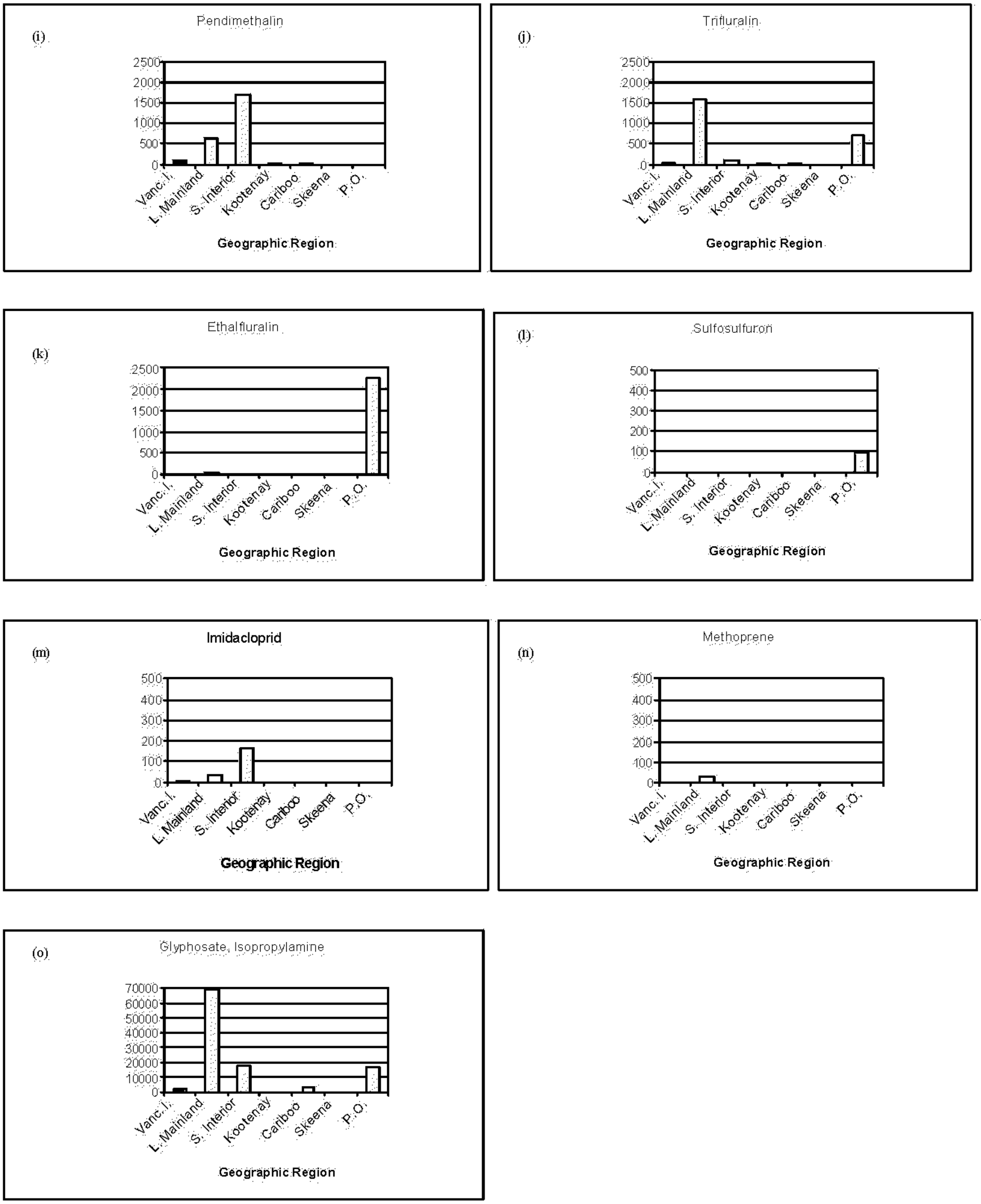


Figure 27 (i-o): Quantity (kg) of reportable pesticides of concern (PMRA shortlist) sold in BC in 1999 by region (ENKON Environmental Limited 2001).

2.5.2 List 2 – Georgia Basin Ecosystem Initiative /Environment Canada's 1998 list of toxic substances in the lower Fraser/Georgia Basin.

This list was developed by the Toxics Work Group (TWG). The TWG was formed under the Puget Sound-Georgia Basin International Task Force and is co-chaired by Environment Canada and BC MWLAP. The nominating list originally consisted of 44 toxic substances found in the lower Fraser/Georgia Basin and were identified as an environmental concern by various agencies and stakeholders. Approximately one half of the 44 substances identified were pesticides. In two of the Enkon reports (1999; 2001), 20 pesticides were identified and an additional four were added based on recommendations in the Enkon (ENKON Environmental Limited 1999) report (mancozeb, a probable endocrine disrupter; captan, a possible mutagen; diazinon, highly toxic) and personal communications with Mike Wan from Environment Canada (chlorothalonil). For clarity, the table was then divided into two sections (reportable pesticides (18) and wood preservatives and anti-sapstains (6) (Tables 13a and 13b). It should be noted that the substances identified by the TWG were not based on their potential to bioaccumulate or persist in the environment.

Of those identified in Table 13a only six have exhibited a sales increase since 1991, including chlorothalonil, diazinon, mancozeb, non/octylphenoxypolyethoxyethanol and surfactant blend. These 18 pesticides represent 17.2% of the total amount of all reportable pesticide sales in 1999, and have increased in use by 10.3%. Since 1991 however, the 18 pesticides mentioned represent 4, 7, and 6 times *less* than the corresponding amounts of wood preservatives and anti-sapstains used in 1991, 1995 and 1999.

With the exception of PCP, wood preservatives (creosote, copper chromated arsenate (CCA), and ammoniacal copper arsenate (ACZA)) have increased in use. However, anti-sapstain (didecyl-dimethyl ammonium chloride (DDAC) and 3-iodo-2-propynyl butyl carbamate (iodocarb) (IPBC)) use has slightly decreased. Most plants are located in the Lower Mainland and Southern Interior with no treatment plants on Vancouver Island or in the Peace-Omineca regions.

Table 13a: 18 reportable pesticides identified in GBEI/Environment Canada's 1998 nominating list of toxic substances in the lower Fraser/Georgia Basin (ENKON Environmental Limited 1999); sales figures obtained from (ENKON Environmental Limited 2001).

Pesticide Classification	Active Ingredient	Quantity of Reportable Sales (kg)			Percent of All Total Reportable Sales (%)			Percent Change in Sales from 1991 to 1999 (%)
		1991	1995	1999	1991	1995	1999	
Herbicide	Atrazine	22,898	10,928	9,991	2.50	1.09	0.91	-56.4
	Dinoseb	7,233	6	48	0.79	0.001	0.004	-99.3
	Simazine	9,048	10,639	8,079	0.99	1.06	0.74	-10.7
	Trifluralin	5,857	4,125	2,347	0.64	0.41	0.21	-59.9
	Metolachlor	10,727	6,807	5,621	1.17	0.68	0.51	-47.6
Insecticide	Diazinon	19,643	22,552	24,563	2.14	2.24	2.25	25.0
	Endosulfan	6,857	7,308	4,712	0.75	0.73	0.43	-31.3
	Lindane (gamma-BHC)	326	272	239	0.04	0.03	0.02	-26.7
	Malathion	12,094	6,523	6,691	1.32	0.65	0.61	-44.7
	Methoxychlor	171	65	56.7	0.02	0.01	0.01	-66.8
	Parathion	4,054	3,969	3,792	0.44	0.39	0.35	-6.5
Fungicide	Captan	28,451	29,160	27,498	3.10	2.90	2.52	-3.3
	Chlorothalonil	3,721	15,871	26,640	0.41	1.58	2.44	615.9
	Mancozeb	29,511	41,907	44,682	3.22	4.17	4.09	51.4
Acaricides	Fenbutatin oxide	206	350	79	0.02	0.03	0.01	-61.7
Other	Nonylphenoxypoly-ethoxyethanol	5,585	8,929	9,245	0.61	0.89	0.85	65.5
	Octylphenoxypoly-ethoxyethanol	2,564	5,957	4,680	0.28	0.59	0.43	82.5
	Surfactant blend	1,340	3,242	8,896	0.15	0.32	0.81	563.9
Total		170,286	178,610	187,866	18.57	17.77	17.18	10.3
Total Quantity of ALL Reportable Pesticides by Year		916,933	1,005,086	1,093,195				19.2

Table 13b: Four wood preservatives, and two anti-sapstains, identified in GBEI/Environment Canada's 1998 nominating list of toxic substances in the lower Fraser/Georgia Basin (ENKON Environmental Limited 1999); sales figures obtained from (ENKON Environmental Limited 2001)).

Active Ingredients	Total Quantity (kg)			Percent Change in Sales from 1991 to 1999 (%)
	1991	1995	1999	
Wood Preservatives				
Creosote	1,690,998	5,869,461	5,387,791	218.62
CCA	651,134	912,392	923,987	41.90
ACZA	500	909	16,488	3197.60
PCP	789,110	122,966	201,642	-74.45
Anti-Sapstains				
DDAC	371,159	455,954	310,051	-16.46
IPBC	28,291	35,248	26,569	-6.09
Total	3,531,191	7,396,930	6,866,528	94.45

2.5.2.1 List 3 – World Wildlife Fund and Pesticide Action Network Europe endocrine disrupting chemical list.

The entire World Wildlife Fund (WWF) and Pesticide Action Network (PAN) Europe list identifies 105 active ingredients (Table 14). These include 39 insecticides, 28 herbicides, 15 fungicides, and 4 other compounds identified by the WWF, as well as19 active ingredients identified by the PAN Europe. Of the 105, 48 (46%) were sold or used in BC in 1999.

Table 14: A list of endocrine disrupting pesticides identified by the WWF and from the PAN Europe. Pesticides shown in bold italics were sold or used in BC in 1999 (World Wildlife Fund Canada 1999; ENKON Environmental Limited 2001; PAN - UK and Lyons 1999; Johannessen and Ross 2002).

Insecticides

Aldrin
Befenthrin
Carbaryl
Carbofuran
Chlordane
Chlordecone
Chlorfentezine
1-cyhalothrin
Deltamethrin
DDT and metabolites
DBCP
Dicofol
Dieldrin
Dimethoate
Dinitrophenol
Endosulfan
Ethofenprox
Fenitrothion
Fenvalerate
Fipronil
beta-HCH
toxaphene
Heptachlor
H-epoxide
Endrin
Lindane (gamma-HCH)
Malathion
Methomyl
Methoxychlor
Mirex
Oxychlordane
Parathion
Photomirex
Pyrethrins
Synthetic pyrethroids
Ronnel (fenclorfos)
Aldicarb
trans-nonachlor
n-2-fluorenylacetamide

Herbicides

2,4-D
2,4,5-T
Acetochlor
Alachlor
Amitrole
Atrazine
Bromacil
Bromoxynil
Cyanazine
DCPA
Ethiozin
Glufosinate-ammonium
Ioxynil
Linuron
Metribuzin
Molinate
Nitrofen
Orysalin
Oxyacetamide
Paraquat
Pendimethalin
Picloram
Pronamide
Simazine
Terbutryn
Thiazopyr
Triclorobenzene
Trifluralin

Others

Ethylene thiourea (ETU)
Pentachlorobenzene
Pentachlorophenol (PCP)
Piperonyl butoxide

Fungicides

Benomyl
Etridiazole
Fenarimol
Fenbuconazole
Hexachlorobenzene
Mancozeb
Maneb
Metiram
Nabam
Pentachloronitrobenzene
Triadimefon
Tributyl-tin
Vinclozolin
Zineb
Ziram

Pan Pesticides

Amitraz
Carbendazim
Chlorpyrifos
Demeton-s-methyl
Dichlorvos
Epoxyconazole
Fentin acetate
Glyphosate
Metam sodium
Oxydemeton-methyl
Penconazole
Prochloraz
Procymidone
Prometryne
Propiconazole
Thiram
Triphenyltin
Trichlorfon
Tridemorph

2.5.3 List 4 –EC/BC MWLAP top 20 active ingredients sold or used in British Columbia in 1991, 1995, and 1999 (excluding domestic pesticides) (ENKON Environmental Limited 2001).

Twenty active ingredients comprised 95% of the total pesticides sold or used in BC in 1999 (also discussed in Pesticide Use in British Columbia; (ENKON Environmental Limited 2001)), most of which have increased dramatically during the survey period 1991-1999 (Table 4 and 15). Fifteen of the 20 ingredients have been identified in lists (1-6) mentioned in this section of the report as pesticides of concern.

Table 15: Quantity of top 20 pesticide active ingredients sold or used in British Columbia in 1991, 1995 and 1999 (excluding domestic pesticides). ((ENKON Environmental Limited 2001) – Appendix B and E).

Active Ingredients	1991 Sales (kg)	1995 Sales (kg)	1999 Sales (kg)	Percent Change in Sales from 1991 to 1999
Creosote	1,690,998	5,869,461	5,387,761	218.61
CCA	651,134	912,392	923,987	41.90
DDAC	371,518	455,954	310,046	-16.55
Mineral Oil (Insecticidal or Adjuvant)	162,245	206,440	261,845	61.39
PCP	789,110	122,966	201,642	-74.45
Borax, all forms	87,800	187,823	142,578	62.39
Glyphosate, Isopropylamine	110,157	124,698	108,763	unknown*
Mancozeb	29,511	41,907	44,682	51.41
Sulphur	28,101	26,319	36,393	29.51
Mineral Oil (Herbicidal or Plant Growth regulator)	38,540	25,215	35,260	-8.51
Metam	27,437	20,422	30,855	12.46
Captan	28,451	29,160	27,498	-3.35
Glyphosate Acid	n/a	n/a	26,810	unknown*
Chlorothalonil	3,721	15,871	26,640	615.94
IPBC	28,291	35,248	26,569	-6.09
Formaldehyde	3,007	14,342	25,495	747.86
Diazinon	19,643	22,552	24,563	25.05
Metiram	27,618	20,874	23,890	-13.50
Bacillus thuringiensis, Serotype H-14	3,188	11,270	21,875	586.17
Bacillus thuringiensis, Berliner spp. *Kurstaki*	3,095	12,283	17,895	478.19

Chromated copper aresenate (CCA), didecyl dimethyl ammonium chloride (DDAC), pentachlorophenol (PCP) and iodocarb (IPBC).
*Values for glyphosate acid were included in the values shown for glyphosate, isopropylamine for years 1991 and 1995 therefore percent change in sales from 1991 to 1999 were not able to be determined. However the overall change in sales for both forms of glyphosate was 23%.
n/a = not available.

2.5.4 List 5 – Fisheries and Oceans Canada priority pesticide list (killer whales).

Grant and Ross (2002) examined contaminants that could present a health risk to southern resident killer whales in the BC/Washington environment. The report identified a list of pesticides that are largely not restricted in Canada but may be persistent and bioaccumulate in the environment and therefore presents a possible health risk to biota (Table 16). Note that several of the PMRA pesticides of concern appear on this list (chlorpyrifos, endosulfan, pendimethalin, triallate, trifluralin, and ethalfuralin) and that lindane and quinfozane were not sold or used in BC in 1999.

Table 16: Pesticides (and their physico-chemical characteristics) that may present a health risk to aquatic biota: largely restricted, persistent and bioaccumulative. Source: (Grant and Ross 2002); original source from (Tomlin 2000).

Pesticide Name	Soil Half-life (days)	Vapour Pressure (mPa)	Water Solubility (mg/L)	Kow
Insecticides				
Chlorpyrifos	33-56	3 (25°C)	2 (25°C)	4.70
Dicofol	60-100	Negliable at rt	0.8 (35°C)	4.28
Endosulfan	150-240	0.83 (20°C)	0.32 (22°C)	3.13
Esfenvalerate	4-287	0.002 (25°C)	<0.3 (25°C)	6.22
Fenthion	~2	0.74 (20°C)	4.2 (20°C)	4.84
Fenvalerate	75-80	0.02 (25°C)	<0.3 (25°C)	6.22
Lindane	60-150	0.05 (20°C)	64 (20°C)	3.00
Permethrin	<38	0.0015 (20°C)	0.2 (20°C)	6.10
Phorate	7-10	85 (20°C)	50 (25°C)	3.92
Herbicides				
Ethalfluralin	25-46	11 (25°C)	0.3 (20°C)	5.11
Oxadiazon	30-180	0.13 (20°C)	0.7 (20°C)	4.91
Pendimethalin	90-120	4 (25°C)	0.3 (20°C)	5.18
Triallate	56-77	16 (25°C)	4 (25°C)	4.60
Trifluralin	57-126	6.1 (25°C)	<1 (27°C)	5.07
Fungicides				
Quintozene	120-300	12.7 (20°C)	0.1 (20°C)	4.46
Pentachlorophenol	45	116,000 (100°C)	80 (20°C)	5.12

rt = room temperature

2.5.5 *List 6 – Fisheries and Oceans Canada priority pesticide list (late-run sockeye).*

Johannessen and Ross (2002) examined environmental contaminants in the Fraser River and their possible risk to late-run sockeye. Contaminants of concern were prioritized based on whether there was evidence of increasing use and sales of the contaminant in sockeye habitat during the period in question. Again, toxicity was not used in the prioritization due to lack of toxicological information available on sublethal effects of many contaminant classes. Through a unique ranking scheme, a list of pesticides of concern was generated (Table 17).

Table 17: Prioritized list of pesticide active ingredients of concern in the context of the late-run sockeye crisis. Prioritization was based on pesticide sales and use data from Enkon Environmental Limited 2001 (Johannessen and Ross 2002).

2,4-D Amine	Linuron
0-benzyl-p-chlorophenol	Maelic hydrazide
Acephate	Mancozeb
Bacillus thuringiensis, Berliner ssp. *Kurstaki*	Mecoprop amine
Bacillus thuringiensis, Serotype H-14	Metalaxyl
Bentazon	Metam
Chlormequat	Napropamide
Chloropicrin	Nonylphenoxypolyethoxyethanol
Chlorothalonil	Oxadiazon
Cupric hydroxide	Paraffin base Mineral Oil
Dazomet	Paraquat
Diazinon	Permethrin
Diquat	Propiconazole
Dodemorph-acetate	Soap (insecticidal)
Formaldehyde	Terbufos
Iprodione	Vinclozolin

2.6 ANALYSIS

The six priority lists (Tables 12 to 17) were cross-referenced to determine overlap. There appears to be a reasonable overlap on the potential pesticides of concern in BC. Overlap among the lists was then assessed through a summation of rank scores (1 – 6) (Table 18). Tallied scores were used to rank the active ingredient in terms of priority based on the original lists provided (Table 19). However, little information was available on newer pesticides used in BC, such as azoxystrobin and kresoxim-methyl (fungicides). This may have resulted in an underestimation of the potential risks associated with these (and other) new products. Our list was then cross-referenced with that from the Enkon 2001 report, and pesticides not sold or used in British Columbia in 1999 were removed. However, newer pesticides (introduced after 1999) known to be currently used in the province were kept on the list and were italicised for their identification.

Table 18: An integrated pesticide list of active ingredients identified in lists 1-6, and a summary score based on the number of times the ingredient was cross-referenced among these six lists.

Active Ingredient	List 1	List 2	List 3	List 4	List 5	List 6	Tally
0-benzyl-p-chlorophenol						X	1
1-cyhalothrin or cyhalothrin lambda				X			1
2,4-D Amine						X	1
Acephate						X	1
Amitraz				X			1
ACZA		X					1
Atrazine	X	X					2
Azoxystrobin	X						1
Bacillus thuringiensis, Serotype H-14			X			X	2
Bacillus thuringiensis, Berliner ssp. *Kurstaki*			X			X	2
Bentazon						X	1
Borax, all forms			X				1
Captan		X	X				2
Carbaryl				X			1
Carbofuran				X			1
Chlormequat						X	1
Chlorothalonil	X	X	X			X	4
Chloropicrin						X	1
Chlorpyrifos	X			X	X		3
CCA		X	X				2
Creosote		X	X				2
Cupric hydroxide						X	1
Dazomet						X	1
Deltamethrin				X			1
Diazinon	X	X	X			X	4
Dichlorvos				X			1
Dicofol				X	X		2
DDAC		X	X				2
Dimethoate				X			1
Dinoseb		X					1
Diquat						X	1
Dodemorph-acetate						X	1
Endosulfan	X	X		X	X		4
Esfenvalerate					X		1
Ethalfluralin	X				X		2
Fenbutatin oxide		X					1
Fenitrothion				X			1
Fenthion					X		1
Fenvalerate				X	X		2
Formaldehyde			X			X	2
Glyphosate Acid	X		X	X			3
Glyphoshate, Isopropylamine	X		X				2
Imidacloprid	X						1
IPBC		X	X				2
Iprodione						X	1
Kresoxim-methyl	X						1
Lindane (gamma-HCH)		X			X		2
Linuron						X	1
Maelic hydrazide						X	1
Malathion	X	X		X			3
Mancozeb		X	X			X	3

Table 18 continued…

Active Ingredient	List 1	List 2	Table X	List 3	List 4	List 5	Tally
Mecoprop amine						X	1
Metam			X	X		X	3
Metalaxyl						X	1
Methomyl				X			1
Methoprene	X						1
Methoxychlor		X		X			2
Metiram			X				1
Mineral Oil (Herbicidal or Plant Growth regulator)			X				1
Mineral Oil (Paraffin Based)						X	1
Mineral Oil (insecticidal or adjuvant)			X				1
Metolachlor		X					1
Napropamide						X	1
Nonylphenoxypolyethanoxyethanol		X				X	2
Octylphenoxypolyethanoxyethanol		X					1
Oxadiazon					X	X	2
Paraquat						X	1
Parathion		X		X			2
Pendimethalin	X			X	X		3
Pentachlorophenol		X	X		X		3
Permethrin					X	X	2
Phorate					X		1
Picloram				X			1
Piperonyl butoxide				X			1
Prometryne				X			1
Propiconazole				X		X	2
Pyraclostrobin	X						1
Quintozene					X		1
Simazine		X		X			2
Soap (insecticidal)						X	1
Sulphur			X				1
Sulfosulfuron	X						1
Surfactant blend		X					1
Terbufos						X	1
Thiram				X			1
Triallate	X				X		2
Trichlorfon				X			1
Trifluralin	X	X		X	X		4
Vinclozolin						X	1

Table 19: Pesticides of concern based on a weighted combination of six agency lists (Table 18).

High Priority*	Low Priority***
Chlorothalonil	0-benzyl-p-chlorophenol
Diazinon	1-cyhalothrin
Endosulfan	2,4-D Amine
Trifluralin	Acephate
	Amitraz
	ACZA
	Azoxystrobin
	Bentazon
	Borax, all forms
	Carbaryl
	Carbofuran
	Chlormequat
	Cupric hydroxide
	Dazomet
	Deltamethrin
	Dichlorvos
	Dimethoate
	Dinoseb
Moderate Priority**	Diquat
	Dodemorph-acetate
Atrazine	Esfenvalerate
Bacillus thuringiensis, Serotype H-14	Fenbutatin oxide
Bacillus thuringiensis, Berliner ssp. *Kurstaki*	Fenitrothion
Captan	Fenthion
Chlorpyrifos	Imidacloprid
CCA	Iprodione
Creosote	Kresoxim-methyl
Dicofol	Lurion
DDAC	Maelic hydrazide
Ethalfluralin	Mecoprop amine
Fenvalerate	Metalaxyl
Formaldehyde	Methoprene
Glyphosate Acid	Metiram
Glyphosate, Isopropylamine	Metolachlor
IPBC	Mineral Oil (Herbicidal or Plant Growth regulator)
Lindane (gamma-HCH)	Mineral Oil (Paraffin Based)
Malathion	Mineral Oil (insecticidal or adjuvant)
Mancozeb	Napropamide
Metam	Octylphenoxypolyethoxyethanol
Methoxychlor	Paraquat
Nonylphenoxypolyethoxyethanol	Picloram
Oxadiazon	Piperonyl butoxide
Parathion	Prometryn
Pendimethalin	Pyraclostrobin
PCP	Quintozene
Permethrin	Soap (insecticidal)
Propiconazole	Sulphur
Simazine	Sulfosulfuron
Triallate	Surfactant blend
	Terbufos
	Thiram
	Trichlorfon
	Vinclozolin

*High Priority: pesticide active ingredients found on four or more of the six priority lists assessed.
** Moderate Priority: pesticide active ingredients found on two or three of the six priority lists assessed.
*** Low Priority: pesticide active ingredients found on one of the six priority lists assessed.
Phorate and Chloropicrin removed as no history of use in BC or indication of its use since 1999.

3.0 CONCLUSIONS

3.1 TRENDS IN THE USE OF PESTICIDES OF CONCERN IN THE PACIFIC REGION

To determine pesticides of potential concern from an aquatic ecosystem/ DFO Pacific Region perspective, the scored active ingredients identified in Table 19 were used, and the total reportable sales by region and the change in sales was determined for each pesticide using the 1999 and 2001 reports (Norecol Environmental Consultants Ltd. 1993; ENKON Environmental Limited 2001) (Appendix F). Wood preservatives and anti-sapstain products were removed, as figures reflected amount used rather than sales reported. Also, these products are used to treat timber within the region identified; however products are then shipped worldwide, such that pesticide use data does not necessarily portray actual loadings to the regional environment. Although the actual amount of treated timber used in each region of the province is not known, wood preservatives and anti-sapstains should be a concern to the Pacific Region due to the large quantities of treated timber believed to be used in marine and aquatic environments and the near-field effects that PAHs have on biota (Goyette and Brooks 1998).

Mineral oils and insecticidal soaps were also removed (Appendix F) as they are considered to have a low toxicity to the aquatic biota. Sales figures were determined for each of the remaining pesticides identified in Table 19, and pesticides were grouped according to their sales figures in 1999 as follows: pesticides heavily used (greater than 10,000 kg) (Table 20), pesticides moderately used (between 5,000-10,000 kg) (Table 21), pesticides with lesser use (1,000-5,000 kg) (Table 22) and minor use pesticides (less than 1,000 kg) (Tables 23).

Interestingly, only two of the four pesticides that we had initially identified as a high priority (chlorothalonil and diazinon; Table 19), are heavily used in the province, primarily in the Lower Mainland and the Southern Interior. Use of both pesticides increased in between 1991-1999 (Table 20). Sales of endosulfan and trifluralin, the remaining two high priority pesticides, were between 1,000-5,000 kg in 1999 and both decreased during the period 1991-1999 (Table 22). Overall, the region with the greatest use of priority pesticides identified (Table 19) was the Lower Mainland, accounting for 59% of the provincial total, followed by the Southern Interior at 28% (Appendix F).

Table 20: Heavily used (greater than 10,000 kg, sold in 1999) pesticides of concern based on a weighted combination of six agency lists.

Active Ingredient greater than 10,000 kg	Region with Highest Sales (Use) Volume	Change in Total Sales from 1991 to 1999 (kg)	Percent Change in Total Provincial Sales from 1991 to 1999
Formaldehyde	Lower Mainland	22,488	748
Chlorothalonil	Lower Mainland	22,919	616
Bacillus thuringiensis, Serotype H-14	Lower Mainland	18,687	586
Bacillus thuringiensis Berliner ssp. Kurstaki	Southern Interior	14,800	478
Dazomet	Lower Mainland	6,585	191
Glyphosate acid	Peace-Omineca	26,810	100
Mancozeb	Lower Mainland, Southern Interior	15,171	51
Sulphur	Southern Interior	8,292	30
Diazinon	Lower Mainland, Southern Interior	4,920	25
2,4-D amine	Lower Mainland	1,576	13
Metam	Lower Mainland	3,418	12
Glyphosate isopropylamine	Lower Mainland, Southern Interior	-1,394	-1
Captan	Lower Mainland	-953	-3
Metiram	Southern Interior	-3,728	-13

Table 21: Moderately used (5,000 - 10,000 kg, sold in 1999) pesticides of concern based on a weighted combination of six agency lists.

Active Ingredient 5,000 kg to 10,000 kg	Region with Highest Sales (Use) Volume	Change in Total Sales from 1991 to 1999 (kg)	Percent Change in Total Provincial Sales from 1991 to 1999
Cupric hydroxide	Lower Mainland	6,286	991
Surfactant blend	Peace-Omineca	7,556	564
Iprodione	Lower Mainland, Southern Interior	4,273	355
Napropamide	Lower Mainland	3,027	83
Nonylphenoxypolyethanoxyethanol	Lower Mainland	3,660	66
Carbaryl	Southern Interior	1,997	27
Quintozene	Lower Mainland	1,440	25
Simazine	Lower Mainland	-969	-11
Malathion	Lower Mainland	-5,403	-45
Metolachlor	Lower Mainland	-5,106	-48
Atrazine	Lower Mainland	-12,907	-56

Table 22: Lesser used (1,000 - 5,000 kg, sold in 1999) pesticides of concern based on a weighted combination of six agency lists.

Active Ingredient between 1,000 kg - 5,000 kg	Region with Highest Sales (Use) Volume	Change in Total Sales from 1991 to 1999 (kg)	Percent Change in Total Provincial Sales from 1991 to 1999
Terbufos	Lower Mainland	2,263.00	1583
Pendimethalin	Southern Interior	2,089.00	627
Picloram	Southern Interior	1,432.00	434
Metalaxyl	Lower Mainland	2,481.00	253
Paraquat	Lower Mainland	4,817.00	100
Octylphenoxypolyethanoxyethanol	Lower Mainland	2,116.00	83
Linuron	Lower Mainland	1,543.00	78
Acephate	Lower Mainland	543.00	68
Chlormequat	Lower Mainland	555.00	67
Dimethoate	Lower Mainland, Southern Interior	1,276.00	43
Mecoprop amine	Lower Mainland, Southern Interior	651.00	23
Maelic hydrazide	Lower Mainland	549.20	21
Diquat	Lower Mainland	266.00	19
Chlorpyrifos	Lower Mainland	30.20	1
Parathion	Lower Mainland	-262.80	-6
Bentazon	Lower Mainland	-118.60	-8
Endosulfan	Lower Mainland, Southern Interior	-2,146.00	-31
Trifluralin	Lower Mainland	-3,510.00	-60
Triallate	Peace Omineca	-17,296.00	-84
Ethalfluralin	Lower Mainland	-24,628.00	-91

Table 23: Minor use (less than 1,000 kg, sold in 1999) pesticides of concern based on a weighted combination of six agency lists.

Active Ingredient less than 1,000 kg	Region with Highest Sales (Use) Volume	Change in Total Sales from 1991 to 1999 (kg)	Percent Change in Total Provincial Sales from 1991 to 1999
Propiconazole	Lower Mainland	490.39	2724
Dodemorph-acetate	Lower Mainland	425.50	781
Borax, all forms	Lower Mainland	422.40	709
O-benzyl-p-chlorophenol	Lower Mainland	111.37	356
Permethrin	Lower Mainland	380.51	192
Amitraz	Kootenay	32.70	100
Cyhalothrin lambda	Peace Omineca	77.00	100
Imidacloprid	Southern Interior	188.28	100
Oxadiazon	Lower Mainland	298.84	100
Vinclozolin	Lower Mainland	528.00	100
Piperonyl butoxide	Lower Mainland	106.01	76
Thiram	Lower Mainland	66.97	19
Deltamethrin	Lower Mainland	3.09	10
Dichlorvos	Lower Mainland	7.00	5
Prometryne	Lower Mainland	-42.20	-13
Lindane (gamma-BHC)	Lower Mainland	-87.02	-27
Carbofuran	Lower Mainland	-542.92	-53
Dicofol	Southern Interior	-421.95	-57
Fenbutatin oxide	Lower Mainland	-127.25	-62
Methomyl	Lower Mainland	-217.92	-63
Methoxychlor	Lower Mainland	-114.30	-67
Methoprene	Lower Mainland	-77.87	-74
Fenthion	Cariboo	-30.11	-81
Fenvalerate	Cariboo	-6.20	-84
Trichlorfon	Peace Omineca	-24.50	-91
Dinoseb	Lower Mainland	-7,185.00	-99

3.2 PRIORITY PESTICIDES BASED ON LAND USE ACTIVITY

To put into perspective which of the pesticides identified in Tables 19 to 23 represent a possible risk to aquatic ecosystems in the Pacific Region, we cross-referenced our information on high use pesticides (based on 1999 sales/use records, CRISP and NFDP database, crop profiles, and relevant literature) with each of the land use activities reviewed (urban, forestry and agricultural). The following assessment should be of interest, although information on newer pesticides and recent sales/use data (1999 to 2003) are lacking at the time of this report. Our list therefore represents a 'work in progress' and should be the subject of ongoing evaluation as more information becomes available.

3.2.1 Urban/Industrial

Commonly used domestic pesticides have been readily detected in urban streams in North America and may affect the ability of salmon to smell, reproduce, avoid predators, swim or detect prey. These include such active ingredients as 2,4-D, bendiocarb, benomyl, carbaryl, chlorothalonil, dicamba, diazinon, glyphosate, malathion, mecoprop amine, MCPA and quintozene (Section 2.1.1). Landscapers, golf courses, and industrial users can also contribute to urban sources. Common pesticide active ingredients utilized by these sectors include 2,4-D, diuron, glyphosate, mineral oil, triclopyr and quintozene. Of these pesticides mentioned 2,4-D, chlorothalonil, diazinon, glyphosate and MCPA (all forms) had sales of greater than 10,000 kg in BC in 1999 (Table 20) while carbaryl, malathion, triclopyr and quintozene had sales of between 5,000 and 10,000 kg (Table 21). Bendiocarb, benomyl, dicamba, mecoprop amine and diuron sales were less than 5,000 kg and did not appear on our priority pesticide lists (Tables 18-23).

Mineral oils (used as insecticides or adjuvants) had total sales of 261,845 kg in 1999 but require further investigation as to their potential to enter waterways and their toxicity to fish. Diuron use on railways is currently being challenged by the Sierra Legal Defence Fund (Appendix H). Environment Canada is also monitoring the movement and leaching potential of both bromacil and diuron along railway rights-of-way in coastal BC as well as the potential contamination of glyphosate and aminomethylphosphonic acid (AMPA) to nearby waterways from spray drift during application (Wan 2003). A recent ruling by a US District Judge banned the application of 38 pesticides along Northwest salmon streams and required retailers in major US West Coast cities to post warning signs where seven of the most harmful (2,4-D, carbaryl, diazinon, diuron, malathion, triclopyr and trifluralin) are sold (Welch 2004).

3.2.2 Forestry

A potential important route of entry of forestry pesticides into the aquatic/marine environment is via aerial application. Our review of the active ingredients used in BC forestry and the relevant literature (Section 2.1.2) identified the following are of potential concern in BC and the Yukon: carbaryl, glyphosate, triclopyr and possibly the surfactants used in *Bacillus thuringiensis*. The latter surfactants remain undisclosed and previous studies have demonstrated a risk to fish habitat from their use in other regions (Fairchild *et al.* 1999; Lewis 1991; Renner 2002). High-use regions in BC include the Southern Interior and the Thompson, in particular. The primary active ingredients used in this area are aerially-applied *Bacillus thuringiensis* and glyphosate, as well as ground treatments of triclopyr and picloram. The Sierra Legal Defence Fund is currently challenging the use of both glyphosate and triclopyr in the forestry sector (Appendix H) (Werring 2003). Although triclopyr is currently permitted for ground treatment only, there has been increasing pressure from industry for BC MWLAP to permit aerial spraying (Cronin 2003).

We also identified fenitrothion as a potential concern, as there seemed to be a discripancy between the forestry datasets (National Forestry Database Program (NFDP) and the BC MWLAP CRISP database). The NFDP indicates high use of aerially applied fenitrothion in the late 1990s and into the early 2000s. However, the CRISP database from BC MWLAP does not indicate that permits were issued for its use. Both triclopyr and fenitrothion would be of significant interest to Fisheries and Oceans researchers due to their high toxicity to fish and the high probability of reaching fish-bearing streams during aerial application. This anomaly needs to be investigated further and action needs to be taken to clarify data records.

Implementation of best management practices in treatment facilities has led to a large decrease in the amount of wood preservatives and anti-sapstains entering the aquatic environment from treatment plants. There is a minimal probability of direct application to water. However, the leachability of wood preservatives does warrant concern, especially considering the extensive use of these compounds in BC. Despite its ban in the 1990s and its declining use, PCP remains a significant concern since it continues to be used in large quantities.

3.2.3 Agriculture

It remains difficult to accurately assess the quantities of agricultural pesticides used in BC, where a large diversity of crops are grown, a wide variety of pesticide products are available for use, a diversity of biogeoclimatic zones that affect pesticide fate exists, and a variety of application methods and crop varieties exist within a geographical area. Pesticide-related problems have been associated with both cranberry and ginseng crops. However, these represent only two of many crops grown in BC. Based on Lower Mainland (Fraser Valley) and Southern Interior use (Section 2.1.3), heavily used pesticides of concern in the agricultural sector are 2,4-D, atrazine, captan, carbaryl, chlorothalonil, diazinon, glyphosate, iprodione, metolachlor, and simazine. Atrazine, iprodione and metolachlor have had sales between 5,000 to 10,000 kg in 1999 and have high application intensities (Table 10 and Appendix D). Of these, a significant decrease in sales/use has only been evident for atrazine and metolachlor. Four other high-use and high-priority pesticides (chlorpyrifos, ethalfluralin, pendimethalin and trifluralin; Tables

10 and 19) were also highlighted. However total sales for each were well below 5,000 kg. The use of both ethalfluralin and trifluralin has decreased significantly over the past decade (Table 22), while chlorpyrifos has remained relatively stable. Pendimethalin use increased substantially over the past decade and may be of concern, despite its relatively low use in 1999. These pesticides are a concern due to their high use by various agricultural crops, their application within proximity to fish bearing waters, and their chemical and physical properties (Appendix I).

Additional research is currently being carried out in the Georgia Basin on both atrazine and endosulfan (Appendix H) (Lim 2003). Environment Canada is also measuring endosulfan residues in the aquatic environment in the Lower Fraser Valley and assessing the risk to non-target organisms.

3.3 KNOWLEDGE GAPS

Through the process of summarizing current pesticide use in the Pacific Region, we encountered several obstacles. The sources of some of these challenges were national or international in scope, while others were due to regional limitations. Outlined below are knowledge gaps identified in the preparation of this report:

National and International Pesticide Information Gaps:

- Limited knowledge on the toxicological effects of all pesticide classes.
- Toxicity testing and data presentation is not standardized, making it difficult to compare relative risks of different pesticides.
- Limited knowledge on the toxicity of breakdown products of pesticides, "inert" ingredients and chemical impurities used in pesticide formulations.
- Limited understanding of the movement of newer pesticides through atmospheric processes and subsequent deposition into aquatic environments.
- Little understanding of the bioaccumulation potential of newer pesticides in aquatic biota and marine food webs.
- Little understanding of the effects of newer pesticides on fish and marine mammals.

Regional Information Gaps:

- Little understanding of salmon sensitivity and multi-habitat use in relation to pesticide use.
- Insufficient information on pesticide use by region. A digital record of such information in the form of GIS (geographical information system) would be ideal.
- No information is available on recent (1999-2003) domestic use (sales or use). Past surveys represent useful tools, but are based on certain assumptions and extrapolation.
- Products treated with leachable pesticides (such as treated wood) which are purchased interprovincially or internationally not are accounted for.
- Pesticides used in the Pacific Region but purchased from out-of-province could not be assessed.
- Limited understanding of *in situ* effects of pesticides on the health of BC fish, as little *field-based* toxicological work has been conducted.

While we know that approximately 286 active pesticide ingredients are used in BC every year, we do not know how the resulting complex mixture of parent compounds and their metabolites affects freshwater and marine biota and their habitat or what the cumulative impact of these pesticides may be. Despite laboratory research on the effects of pesticides on aquatic organisms, there appears to be very little *in situ* research on the effects of pesticides used within a watershed and their detection in salmonid habitat. The relationship between laboratory studies and the *in situ* environment is weak and needs to be strengthened to determine the full potential impact of current use pesticides (CUPs) on salmonids. The unknown effects of pesticides in the environment are complicated further by the complex life cycle of salmonids and the effects of pesticide exposure during their various life stages.

3.4 RESEARCH NEEDS

We contacted a number of researchers and organizations in order to identify current research initiatives and needs in the Pacific Region. Researchers identified their current pesticide research and monitoring efforts (as presented in Appendix H) and research needs from the perspective of their organization. Where applicable, several researchers within one organization were contacted (e.g. Environment Canada's Canadian Wildlife Service, Environmental Quality Branch, National Water Research Institute, Air Quality Research Branch).

3.4.1 *Environment Canada*

1) Subtle effects of selected in-use pesticides, especially their transformation products, on indicator organisms, using toxicogenomic methodology.
2) Development of reliable analytical techniques to recover environmental residues of transformation products of selected CUP.
3) Analytical capabilities to address CUPs and their breakdown products in the environment.
4) Toxicity of CUPs to local species at relevant environmental concentrations.
5) Who is spraying what, how much is being sprayed, and when and where are they spraying?
6) Effects of sublethal concentrations of wood preservatives/pesticides in the aquatic environment. Are the best management practices (BMP) in place adequate to protect aquatic life, and are they being used properly?
7) Effects of copper based boat paints on the receiving environment.
8) Effectiveness of sampling and tools, such as commercially available Polar Organic Chemical Integrated Sampler (POCIS), for detecting non-polar pesticide contamination in fish bearing waters after a pesticide application is made.

3.4.2 *Fisheries and Oceans Canada*

1) The "inert ingredients" of pesticide formulations may not be as inert as we would like to think, and the effects may be subtle enough that they are hard to detect. Thought should be given as to how to test/screen compounds for effects more subtle than a fish kill. Much of this has been started through discussions on how to deal with EDCs, low dose, and/or chronic exposures.
2) How to better assign causality in relationships where contaminants may be affecting fish or fisheries resources? The level of evidence needed to argue that there are effects is hard to obtain in the real world where multiple effects, multiple stressors, and all the interactions of space, time and ecology are at work.
3) Salmonids at smolting may be susceptible to a wide range of contaminants whose mode of action is not yet clear. The gathering evidence is that these stressors (aluminum, episodic low pH, EDCs such as nonylphenol) acting on smolts while in freshwater can act to reduce marine survival. The complex mixture that is present in

the water near the mouth of the Fraser River contains many candidates that could be influencing marine survival of salmon smolts.

3.4.3 Health Canada

Phase I monitoring needs are those which identify pesticides entering groundwater and surface waters. This information would aid PMRA in the re-evaluation program for pesticides of concern (high detection frequency linked with high hazard/risk). This data would also be useful as indicators of trends in pesticide concentration over time. In addition, the monitoring data acts as a performance measure for mitigative methods associated with some pesticide products (i.e. no-spray buffer zones for reducing entry into aquatic systems).

Phase II monitoring needs would determine whether acute and/or chronic effects are observed in biota under field conditions. This monitoring would be based largely on the detection of effective acute and/or chronic concentrations determined in Phase I- surface waters. Monitoring would include residues in biota and effects in areas where pesticides are found (as per Phase I); survey of effects of surface runoff on aquatic biota using *in situ* biomonitors; and a survey of effects of pesticide spray drift on biota using *in situ* biomonitors.

3.4.4 Natural Resources Canada - Pacific Forestry Centre

Research at the Pacific Forestry Centre focuses on biological pesticide research with particular focus on *Bacillus thuringiensis* to date no research needs have been identified.

3.4.5 Simon Fraser University

1) Mechanisms of pesticide impacts to determine cause-effect relationships and links to population levels effects.
2) Toxicokinetic and environmental fate models for pesticides.
3) Mapping of overall pesticide expenditures by municipality (from Vancouver, BC to Hope, BC) based on agricultural census data.
4) Stormwater detention and water sampling for pesticides.
5) Development of analytical methodologies for the detection of atrazine and other CUPs.

3.4.6 Capital Regional District

There seems to be a lack of information on environmental effects of commonly used pesticides (either the products used by the agricultural community on a regular basis or the ones that can be purchased from a garden store for general use). With that in mind CRD has identified the following questions:

1) What pesticides are the most commonly used and could have environmental effects?
2) What effects (acute or chronic) do these commonly-used pesticides have on aquatic and terrestrial ecosystems (i.e. to the different components of these ecosystems)?
3) At what concentrations (or levels) do these pesticides cause a significant effect and are these concentrations observed in the receiving environment?
4) Do some of these commonly-used compounds react or act in a synergistic manner to cause effects/impacts?

3.4.7 Greater Vancouver Regional District

Have not identified any research needs at this time.

3.4.8 Georgia Strait Alliance

1) Long-term and cumulative effects of pesticides. Need to understand how all these pesticides will affect us over a long period of time. There are also gaps in our knowledge regarding how pesticides react with other compounds. For example DEET. One study says it is safe for kids to use. The next study finds that together with suntan lotion the absorption rate of DEET doubles. A small dose may be fine but we are constantly exposed to many different pesticides.

2) Run-off effects of pesticides, on water quality and fish. We can surmise what the impacts will be but knowing the exact impacts is critical. Monitoring of pesticide levels in fish and water over the long term would be helpful.

3.4.9 Sierra Legal Defence Fund

Staff at the Sierra Legal Defence Fund has conducted limited work related to pesticides, but not much is related to pesticide monitoring. The following points were with regards to research needs:

1) Increased assessment on the biological impacts of pesticides in the environment and their overall toxicity to aquatic, terrestrial and avian organisms. Currently, only the active ingredients of a pesticide are required to be tested for toxicity. Toxicity of the actual mixture being sprayed is not being adequately assessed.
2) Comparison of baseline (pre-spray, versus sprayed and unsprayed areas) for habitat and species alterations to assess whether there are any impacts to insect, macro-faunal and avian communities.
3) Determine the necessity and cost-effectiveness of pesticide spraying in forested areas.

4.0 SUMMARY

Hundreds of pesticides are used in British Columbia and the Yukon to control or eliminate unwanted pests, weeds and fungi in forestry, agricultural and urban sectors. These chemicals are designed to kill or affect the target species, but non-target organisms are also often vulnerable. Waterways are of particular concern, since hydrological forces influence the movement of both hydrophilic and hydrophobic pesticides.

The Pacific Region of Canada has a wide variety of biogeoclimatic zones, an important forestry sector, a diverse agricultural industry and high human population densities around the Fraser River estuary (Vancouver) and the adjacent Georgia Basin. Characterizing the impact or risk of impact of different pesticides should be based upon a consideration of such features. In this regard the Pacific Region stands out from other parts of Canada as a result of the varied biogeoclimatic zones and a diverse crop variety. No up-to-date list of pesticide quantities used in British Columbia exists, making it exceedingly difficult to conduct even a cursory risk assessment of current use pesticides in the freshwater/marine environments.

In this report, we draw on the results of six past and ongoing efforts to identify priority pesticides of concern in the Pacific Region. In addition, crop profiles from the BC MAFF and pesticide permits/application records from the BC MWLAP were obtained, in order to construct a foundation for this review. Priority lists used here included i) *PMRA-Fisheries and Oceans Canada priority pesticide list (18);* ii) *Georgia Basin Ecosystem Initiative-Environment Canada priority pesticide list (24);* iii) *World Wildlife Fund-Pesticide Action Network Europe endocrine disrupting chemicals list (105);* iv) *Environment Canada and BC MWLAP top 20 pesticides list*; v) *Fisheries and Oceans Canada priority pesticide list relevant to killer whales (16);* and vi) *Fisheries and Oceans Canada priority pesticide list of concern to late-run sockeye (32).*

Our exercise generated three lists of current use pesticides of concern to the Pacific Region aquatic biota as follows i) *pesticides of concern based on a weighted combination of six agency* lists (Table 19); *ii) pesticides of concern based on a weighted combination of six agency lists grouped by 1999 sales figures (Tables 20 to 23);* and *iii) our priority list of 23 current use pesticides of concern by land use sector (Table 24).*

Highlights of our findings:

- Total sales for the PMRA list (i) decreased by 4.4% in BC to 223,295 kg from 1991 to 1999, at which point these pesticides accounted for 20.4% of total reportable pesticide sales.
- Sales of seven of the 18 PMRA listed (i) pesticides increased during this period, while eight decreased, and three had no record of use in BC in 1999.
- Total sales for the GBEI-EC list (ii) increased by 10.3% to 187,866 kg during the period 1991 to 1999, at which point these accounted for 17.2 % of total reportable pesticide sales.

- Sales of six of the 18 GBEI-EC pesticides (ii) increased during this period, while the remaining twelve decreased.
- The significant use of wood preservatives and anti-sapstain compounds is evident for BC pesticides, since these compounds account for the overwhelming majority of total pesticides sold or used in BC (e.g. 6,866,528 kg, or 81.7%, in 1999).
- Of the 85 pesticides identified in the six summary lists, we deemed four pesticides as high priority, 29 as moderate priority, and 53 as low priority based on the literature.
- Of the four pesticides perceived to be a high priority, the use of only two (chlorothalonil and diazinon) increased between 1991 and 1999; these are heavily used in the province, primarily in the Lower Mainland and the Southern Interior.
- Overall, the region with the greatest use of pesticides we deemed as priorities was the Lower Mainland, accounting for 59% of the provincial total, followed by the Southern Interior at 28%.

Pesticides frequently used by the three sectors (urban, forestry and agriculture) were also identified through a variety of literature and data sources and then cross-referenced with our compiled priority pesticide list of concern to aquatic biota (Table 19). Frequently-used pesticides that were identified as problematic or of concern were highlighted by sector (Table 24). A detailed description of each of the pesticides and their chemical characteristics and properties are provided in Appendix I.

Table 24: Our list of 23 currently used pesticides (CUP) of concern by land use sector with seven pesticides used by more than one land use sector.

Urban	2,4-D	Glyphosate
	Carbaryl	Malathion
	Chlorothalonil	MCPA
	Diazinon	Quintozene
	Diuron	Triclopyr
Forestry	Carbaryl	Glyphosate
	CCA	PCP
	Creosote	Surfactants in *Bacillus thuringiensis*
	Fenitrothion	Triclopyr
Agriculture	2,4-D	Endosulfan
	Atrazine	Ethalfluralin
	Captan	Glyphosate
	Chlorothalonil	Pendimethalin
	Chlorpyrifos	Simazine
	Diazinon	Trifluralin

Although some studies have characterized certain persistent organic pollutants (POPs) and organochlorine pesticides in fish, marine mammals, and abiotic compartments of the freshwater/marine environment in BC, little is known about the fate of many "new generation" pesticides and their impacts on the health of aquatic organisms and ecosystems. In addition, little knowledge exists on the fate and effects of carrier compounds in pesticide formulations and the transformation/degradation products or metabolites of the pesticide active ingredients. Organochlorine pesticides have previously been and continue to be associated with incidents of eggshell thinning in fish-eating birds, and endocrine disruption in various vertebrates in British Columbia. Our results suggest that further research is needed into source-transport-fate characterization for various priority pesticides (both old and new, persistent and non-persistent), as well as into adverse health effects in sensitive life stages of invertebrates, salmon, other fish species, and marine mammals.

5.0 REFERENCES

AAL Reference Laboratories, Inc. 1997. Pesticide exposure biological markers: Adverse health effects following chlorpyrifos exposure. http://www.aal.xohost.com/chemexpo.htm

Addison, R. F. and Ross, P. S. 2001. Persistent organic pollutants (POPs) in British Columbia harbour seals and killer whales. Canadian Stock Assessment Secretariat. PSARC Research Document 2000/171. Fisheries and Oceans Canada. Ottawa, Canada.

Agriculture Canada. 1990. Wood treatment materials. C90-10.

Agrocore. Personal Communications. Forage crop pesticides. 2003.

Agrocore United. Personal Communications. Forage crop pesticides. 2003.

Alberta Environmental Protection. 1998. Golf course pesticide use and monitoring - Factsheet. Edmonton, Alberta.

Anton, F. A., Laborda, E., and de Ariz, M. 1994. Acute toxicity of the herbicide glyphosate to fish. Chemosphere **28**: 745-753.

Battershill, J. M. 1994. Review of the safety assessment of polychlorinated biphenyls (PCBs) with particular reference to reproductive toxicity. Human and Experimental Toxicology **13**: 581-597.

Beauvais, S. L., Jones, S. B., Brewer, S. K., and Little, E. E. 2000. Physiological measures of neurotoxicity of diazinon and malathion to larval rainbow trout (*Oncorhynchus mykiss*) and their correlation with behavioral measures. Environmental Toxicology and Chemistry **19**: 1875-1880.

Belzer, W., Evans, C., and Poon, A. 1998a. Atmospheric concentrations of agricultural chemicals in the lower Fraser Valley 1996. DOE FRAP 1997-31. Environment Canada. Vancouver, BC.

Belzer, W., Thomson, R. B., Taylor, G., and Scibek, Y. 1998b. Chemical analyses of snow samples is southwestern British Columbia. DOE FRAP 1997-41. Environment Canada. Vancouver, BC.

Bennis, D. T. 1999. Review of the environmental occurrence of alkylphenols and alkylphenol ethoxylates. Water Quality Research Journal of Canada **34**: 79-122.

Bernt, K. E., Hammill, M. O., Lebeuf, M., and Kovacs, K. M. 1999. Levels and patterns of PCBs and OC pesticides in harbour and grey seals from the St. Lawrence Estuary, Canada. Science of the Total Environment **243/244**: 243-262.

Black, R. W., Haggland, A. L., and Voss, F. D. 2000. Predicting the probability of detecting organochlorine pesticides and polychlorinated biphenyls in stream systems on the basis of land use in the Pacific Northwest, USA. Environmental Toxicology and Chemistry **19**: 1044-1054.

Blais, J. M., Schindler, D. W., Muir, D. C. G., Kimpe, L. E., Donald, D. B., and Rosenberg, B. 1998. Accumulation of persistent organochlorine compounds in mountains of Western Canada. Nature **395**: 585-588.

Blais, J. M., Schindler, D. W., Muir, D. C. G., Sharp, M., Donald, D., Lafreniere, M., Braekeveit, E., and Strachan, W. J. 2001. Melting glaciers: A major source of persistent organochlorines to subalpine Bow Lake in Banff national park, Canada. Ambio **30**: 410-415.

Boateng, J. Personal Communications. Forestry pesticide use. 2003.

Bortleson, G. C. and Davis, D. A. 1997. Pesticides in selected small streams in the Puget Sound Basin, 1987-1995. U.S. Geological Survey Fact Sheet 067-97. U.S. Department of the Interior-U.S. Geological Survey: National Water-Quality Assessment Program.

Bortleson, G. C. and Ebbert, J. C. 2000. Occurrence of pesticides in streams and ground water in the Puget Sound Basin, Washington, and British Columbia, 1996-1998. Water-Resources Investigations Report 00-4118. U.S. Geological Survey. Tacoma, Washington.

Boyd, J., Macdonald, R., Hutton, K., Baumann, J., Bertold, S., and Moore, B. 1997. Burrard Inlet Sediment Core Contaminant Profiles. BIHEAP Environmental Quality Objectives and Monitoring Action Team (EQOMAT) and Ocean Chemistry, Institute of Ocean Sciences.

Brenner, L. 1992. Malathion. Journal of Pesticide Reform **12**: 29-37.

Brewer, S. K., DeLonay, A. J., Little, E. E., Beauvais, S. L., Jones, S. B., and Ellersieck, M. R. 2001. Behavioral dysfunctions correlate to altered physiology in rainbow trout (*Oncorhynchus mykiss*) exposed to cholinesterase-inhibiting chemicals. Archives of Environmental Contamination and Toxicology **40**: 70-76.

British Columbia Ministry of Agriculture, Food and Fisheries. 2002. Agricultural profile for British Columbia.

Brown, T. G. 2002. Floodplains, flooding, and salmon rearing habitats in British Columbia: A review. Canadian Science Advisory Secretariat Research Document. (2002/007).

Bull, C. J. and McInerney, J. E. 1974. Behavior of juvenile coho salmon (*Oncorhynchus kisutch*) exposed to Sumithion (fenitrothion), an organophosphate insecticide. Journal of Fisheries Research Board of Canada **31**: 1867-1872.

Canadian Council of Forest Ministers. 2002. Compendium of Canadian forestry statistics - Section 9: Pest control product use. http://nfdp.ccfm.org/frames2_e.htm.

Canadian Pacific Railway. 2003. Environmental performance: Aquatic protection and vegetation management. http://www8.cpr.ca.

Clark, K. Personal Communications. Forage crop pesticides. 2003.

Colodey, A. G., Hagen, M. E., Boyd, J. M., and Redenbach, A. E. 1999. Pulp and paper environmental effects monitoring (1993-1996): British Columbia cycle 1 synopsis and cycle 2 changes. Regional Program Report: 99-03. Environmental Protection Branch, Environment Canada, Pacific and Yukon Region. North Vancouver, British Columbia.

Coppage, D. L. 1972. Organophosphate pesticides: Specific level of brain AChE inhibition related to dealth in sheepshead minnows. Transactions of the American Fisheries Society **100**: 534-536.

Coppage, D. L. and Mattews, E. 1974. Short-term effects of organophosphate pesticides on cholinesterases of estuarine fishes and pink shrimp. Bulletin of Environmental Contamination and Toxicology **11**: 483-488.

Corporate Environmental Services BC Rail Ltd. 2002. BC Rail integrated vegetation management plan: A pest management plan under the Pesticide Control Act. http://www.bcrail.com/environserv/pestmgmtplan/detail.asp.

Cox, C. 1993. Carbaryl. Journal of Pesticide Reform **13**: 31-29-36/35.

Cox, C. 1998. Herbicide factsheet: Glyphosate (Roundup). Journal of Pesticide Reform **18**: 3-17.

Cox, C. 1999. Inert ingredients in pesticides: Who's keeping secrets? Journal of Pesticide Reform **19**: 2-8.

Cox, C. 2000. Lethal lawns: Diazinon use threatens salmon survival. Oregon Pesticide Education Network. http://www.pesticide.org

Cranston, R. Personal Communications. Forage crop pesticides. 2003.

Cronin, D. Personal Communications. Provincial pesticide use. 2003.

Custer, B. S. 1996. 1996 dioxin and furan monitoring program. Envirochem Special Projects.

Davis, D. 1996. Washington State pesticide monitoring program: 1994 surface water sampling report. 96-305. Washington State, Department of Ecology. Olympia, Washington.

Davis, D. 1998. Washington State pesticide monitoring program: 1996 surface water sampling report. 98-305. Washington State, Department of Ecology. Olympia, Washington.

Davis, D., Serdar, D., and Johnson, A. 1998. Washington State pesticide monitoring program: 1995 fish tissue sampling report. 98-312. Washington State, Department of Ecology. Olympia, Washington.

Donald, D. 1993. Polychlorinated biphenyls and organochlorine pesticides in the aquatic environment along the continental divide region of Alberta and British Columbia. Inland Waters Directorate.

Donald, D., Stern, G. A., Muir, D. C. G., Fowler, B. R., Miskimmin, B. M., and Bailey, R. 1998. Chlorobronanes in water, sediment, and fish from toxaphene treated and untreated lakes in western Canada. Environmental Science and Technology **32**: 1391-1397.

Dubrovsky, N. M., Kratzer, C. R., Brown, L. R., Gronberg, J. M., and Burow, K. R. 1998. Summary of major issues and findings: Water quality in the San Joaquin-Tulare basins, California, 1992-95. USGS Circular 1159.

Eisenreich, S. J., Urban, N. R., Franz, T. F., Hornbuckle, K. C., Achman, D., Rapaport, R. A., and Capel, P. D. 1989. PCBs and chlorinated pesticides in northern Minnesota snow deposition, 1981-1989. Environmental Science and Technology (32nd Conference on Great Lakes Research), 45 .

Elliott, J. E. and Harris, M. L. 2001. An ecotoxicological assessment of chlorinated hydrocarbon effects on bald eagle populations. Reviews in Toxicology **4**: 1-60.

Elliott, J. E., Machmer, M. M., Wilson, L. K., and Henny, C. J. 2000. Contaminants in ospreys from the Pacific Northwest: II. organochlorine pesticides, polychlorinated biphenyls, and mercury, 1991-1997. Archives of Environmental Contamination and Toxicology **38**: 93-106.

Elliott, J. E., Noble, D. G., Norstrom, R. J., and Whitehead, P. E. 1989. Organochlorine contaminants in seabird eggs from the Pacific coast of Canada, 1971-1986. Environmental Monitoring and Assessment **12**: 67-82.

Elliott, J. E. and Norstrom, R. J. 1998. Chlorinated hydrocarbon contaminants and productivity of bald eagle populations on the Pacific coast of Canada. Environmental Toxicology and Chemistry **17**: 1142-1153.

Elliott, J. E., Norstrom, R. J., and Smith, G. E. J. 1996a. Patterns, trends, and toxicological significance of chlorinated hydrocarbon and mercury contaminants in bald eagle eggs from the Pacific coast of Canada, 1990-1994. Archives of Environmental Contamination and Toxicology **31**: 354-367.

Elliott, J. E., Wilson, L. K., Langelier, K. W., and Norstrom, R. J. 1996b. Bald eagle mortality and chlorinated hydrocarbon contaminants in livers from British Columbia, Canada, 1989-1994. Environmental Pollution **94**: 9-18.

ENKON Environmental Limited. 1999. Sources and releases of toxic substances in wastewaters within the Georgia Basin. 1004-003. Prepared for Environment Canada. Surrey, British Columbia.

ENKON Environmental Limited. 2001. Survey of pesticide use in British Columbia: 1999. 1004-005. Environment Canada; Ministry of Environment, Lands and Parks. Surrey, British Columbia.

Fairchild, W. L., Brown, S. B., and Moore, A. 2002. Effects of freshwater contaminants on marine survival in Atlantic salmon. NPAFC Technical Report .

Fairchild, W. L., Swansburg, E. O., Arsenault, J. T., and Brown, S. B. 1999. Does an association between pesticide use and subsequent declines in catch of Atlantic salmon (*Salmo salar*) represent a case of endocrine disruption? Environmental Health Perspectives **107**: 349-358.

Farrell, A. P., Stockner, E., and Kennedy, C. J. 1998. A study of the lethal and sublethal toxicity of polyphase P-100, an antisapstain fungicide containing 3-iodo-2-propynyl butyl carbamate (IPBC), on fish and aquatic invertebrates. Archives of Environmental Contamination and Toxicology **35**: 472-478.

Fisheries and Oceans Canada. 2003. Administrative regions. http://www.dfo-mpo.gc.ca/regions_e.htm.

Fisheries and Oceans Canada - Habitat and Enhancement Branch. 2003. Habitat inventory reports: BC and Yukon Fisheries Information Summary System (FISS) database. http://www-heb.pac.dfo-mpo.gc.ca/maps/maps-data_e.htm.

Folmar, L. C., Sanders, H. O., and Julin, A. M. 1979. Toxicity of the herbicide glyphosate and several of its formulations to fish and aquatic invertebrates. Archives of Environmental Contamination and Toxicology **8**: 269-278.

Fraser River Aboriginal Fisheries Secretrait. 2003. Fraser River salmon information. http://www.frafs.ca.

Fraser River Action Plan. 1998. Forest industries. Environment Canada. Vancouver, BC. http://www.rem.sfu.ca/FRAP/foreste.pdf

Fraser River Action Plan. 1999. Lower Fraser Valley streams strategic review. (1). http://www.rem.sfu.ca/FRAP/PDF_list.

Fraser River Estuary Management Program. 1996. Environmental quality report. FREMP. Burnaby, BC.

Glaser, L. C. 2001. Wildlife mortality attributed to organophos-phorus and carbamate pesticides. National Biological Service.

Government of Canada. Canada watershed maps. 1977.

Government of Yukon Canada. 2003. Yukon at a glance. http://www.gov.yk.ca/.

Government of Yukon Department of Environment. 2003. Welcome to environment Yukon. http://www.environmentyukon.gov.yk.ca/main/index.shtml.

Goyette, D. and Brooks, K. M. 1998. Sooke basin creosote evaluation study. Regional Program Report PR98-04. Environment Canada.

Grant, S. C. H. and Ross, P. S. 2002. Southern resident killer whales at risk: Toxic chemicals in the British Columbia and Washington Environments. Canadian Technical Report of Fisheries and Aquatic Sciences **2412**.

Gruber, S. J. and Munn, M. D. 1998. Organophosphate and carbamate insecticides in agricultural waters and cholinesterase (ChE) inhibition in common carp (*Cyprinus carpio*). Archives of Environmental Contamination and Toxicology **35**: 391-396.

Guite, M. Personal Communications. Pesticide use at BC Hydro. 2003.

Hall, R., Hicklin, J., and Wilson, D. 1995. Pesticide use in the Yukon. Volume 1 - Final report. Environmental Protection and Assessment Branch, Department of Renewable Resources, Government of Yukon.

Hill, T, Beckman, D., Sproule, B, and Fair, B. 2000. Yukon agriculture, state of the industry, 1998-1999. PR-00-02. Department of Renewable Resources, Goverment of Yukon and Agriculture and Agri-Food Canada, Research Branch. http://www.renres.gov.yk.ca.

Hill, T., Beckman, D., Ball, M., Smith, P., and Whelan, V. 2002. Yukon agriculture state of the industry 2000-2001. Department of Energy, Mines and Resources, Government of Yukon, Agriculture and Agri-Food Canada-Research Branch.

Hull, D. J. and Miller, R. A. 2000. Stormwater quality survey: Core area -1999. CRD Environmental Services. Victoria, BC.

Hutton, K. E. and Samis, S. C. 2000. Guidelines to protect fish and fish habitat from treated wood used in aquatic environments in the Pacific region. Canadian Technical Report of Fisheries and Aquatic Sciences **2314**: vi + 34 p.

Johannessen, D. I. and Ross, P. S. 2002. Late-run sockeye at risk: An overview of environmental contaminants in Fraser River salmon habitat. Canadian Technical Report of Fisheries and Aquatic Sciences. (2429).

Johnson, A. and Davis, D. 1996. Washington State pesticide monitoring program: pesticides and PCBs in marine mussels, 1995. Publication No. 96-301. Washington State Department of Ecology. Olympia, Washington.

Johnson, D. W. 1973. Pesticide residues in fish. Environmental pollution by pesticides. Plenum Press, New York.3. 181-212.

Johnston, B. D., Seubert, J. M., and Kennedy, C. J. 1998. Biochemical effects of didecyldimethylammonium chloride (DDAC) exposure and osmoregulatory stress on juvenile coho salmon, *Oncorhynchus kisutch*. Archives of Environmental Contamination and Toxicology **34**: 275-279.

Kannan, K., Senthilkumar, K., Elliott, J. E., Feyk, L. A., and Giesy, J. P. 1998. Occurrence of butyltin compounds in tissues of water birds and seaducks from the United States and Canada. Archives of Environmental Contamination and Toxicology **35**: 64-69.

Kerr, S. R. and Vass, W. P. 1973. Pesticide residues in aquatic invertebrates. *In* Edwards, C. A. (*eds.*). Environmental pollution by pesticides. Plenum Press, New York.3. 134-180.

Kleivane, L., Espeland, O., Fagerheim, K. A., Hylland, K., Polder, A., and Skaare, J. U. 1997. Organochlorine pesticides and PCBs in the east ice harp seal (*Phoca groenlandica*) population. Marine Environmental Research **43**: 117-130.

Kuivila, K. M. 1999. Studies relating pesticide concentrations to potential effects on aquatic organisms in the San Francisco Bay-Estuary, California . U.S. Geological survey toxic substances hydrology program - Proceedings of the technical meeting, Charleston, South Carolina, March 8-12, 1999 - Volume 2 of 3 - Contamination of hydrologic systems and related ecosystems. U.S. Geological Survey Water-Resources Investigations Report 99-4018B. United States Geological Survey. Charleston, South Carolina. http://toxics.usgs.gov/bib/bib-sfbay.html.

Kuivila, K. M. and Foe, C. G. 1995. Concentrations, transport and biological effects of dormant spray pesticides in the San Fransisco estuary, California. Environmental Toxicology and Chemistry **14**: 1141-1150.

Larson, S. J., Gilliom, R. J., and Capel, P. D. 1999. Pesticides in streams of the United States-initial results from the National Water Quality Assessment Program. Water-Resources Investigations Report 98-4222. United States Geological Survey. Sacramento, California.

Leblond, V. S., Bisson, M., and Hontela, A. 2001. Inhibition of cortisol secretion in dispersed head kidney cells of rainbow trout (*Oncorhynchus mykiss*) by endosulfan, an organochlorine pesticide. General and Comparative Endocrinology **121**: 48-56.

Lee, H.-B. and Peart, T. E. 1999. Occurrence of nonylphenol ethoxylates and their metabolites in Canadian pulp and paper mill effluents and sludge. Water Quality Research Journal of Canada **34**: 633-652.

Lewis, M. A. 1991. Chronic and sublethal toxicities of surfactants to aquatic animals: A review and risk assessment. Water Research **25**: 101-113.

Lichota, G., Ross, P. S., and McAdie, M. 2004. Endangered Vancouver Island marmots (*Marmota vancouverensis*): Sentinels of atmospherically delivered contaminants to British Columbia, Canada. Environmental Toxicology and Chemistry **in Press**.

Lim, P. Personal Communications. Pesticide research. 2003.

Little, E. E., Archeski, R. D., Flerov, B. A., and Kozlovskaya, V. I. 1990. Behavioral indicators of sublethal toxicity in rainbow trout. Archives of Environmental Contamination and Toxicology **19:** 380-385.

MacDonald, L. 2003. Measuring integrated pest management adoption in British Columbia 1998 prices: A component of the state of resources survey. BC Ministry of Agriculture, Food and Fisheries. Abbotsford, BC.

Macdonald, R. W., Cretney, W. J., Crewe, N., and Paton, D. 1992. A history of octachlorodibenzo-*p*-dioxin, 2,3,7,8-tetrachlorodibenzofuran, and 3,3',4,4'-tetrachlorobiphenyl contamination in Howe Sound, British Columbia. Environmental Science and Technology **26**: 1544-1550.

Macdonald, R. W., Harner, T., and Fyfe, J. 2003. The interaction of climate change with contaminant pathways to and within the Canadain Arctic. *In* Bidleman, T. F., Macdonald, R. W., and Stow, J. (*eds.*). The Canadian Arctic contaminants assessment report. Department of Indian Affairs and Northern Development, Ottawa. 225-279.

Macdonald, R. W., Mackay, D., and Hickie, B. 2002. Contaminant amplification in the environment. Environmental Science and Technology **December**: 457-462.

Macdonald, R. W., Shaw, D. P., and Gray, C. B. J. 2000. Contaminants in lake sediments and fish. Health of the Fraser River aquatic ecosystem: A synthesis of research conducted under the Fraser River Action Plan. Environment Canada, Vancouver, British Columbia.1. 23-45.

Maguire, R. J. 1999. Review of the persistence of nonylphenol and nonylphenol ethoxylates in aquatic environments. Water Quality Research Journal of Canada **34**: 37-78.

Majewski, M. S. and Capel, P. D. 1995. Pesticides in the atmosphere: Distribution, trends, and governing factors. Ann Arbor Press, Chelsea, Michigan.

Marquardt, S., Cox, C., and Knight, H. 1998. Toxic secrets: "Inert" ingredients in pesticides 1987-1997. Californians for Pesticide Reform.

McBride, J. R., Dye, H. M., and Donaldson, E. M. 1981. Stress response of juvenile sockeye salmon (*Oncorhynchus nerka*) to the butoxyethanol ester of 2,4-dichlorophenoxyacetic acid. Bulletin of Environmental Contamination and Toxicology **27**: 877-884.

McCain, B. B., Myers, M. S., Varanasi, U, Brown, D. W., Rhodes, L. D., Gronlund, W. D., Elliott, D. G., Palsson, W. A., Hodgins, H. O., and Malins, D. C. 1982. Pathology of two species of flatfish from urban estuaries in Puget Sound. Interagency Energy/Environment R&D Program Report. (89).

McLeese, D. W., Zitko, V., Metcalfe, C. D., and Sergeant, D. B. 1980. Lethality of aminocarb and the components of the aminocarb formulation to juvenile Atlantic salmon, marine invertebrates and a freshwater clam. Chemosphere **9**: 79-82.

Mikkelson, P., Passivirta, J., Rogers, I. H., and Ikonomou, M. 1996. Studies on eulachon tainting problem: Analyses of tainting and toxic aromatic pollutants. *In* Servos, M. R., Munkittrick, K. R., Carey, J. H., and Van der Kraak, G. J. (*eds.*). Environmental fate and effects of pulp and paper: Mill effluents. St. Lucie Press, Delray Beach, Florida.

Mineau, P. (*eds.*). 1991. Cholinesterase-inhibiting insecticides: Their impact on wildlife and the environment. Chemicals in agriculture. (Vol. 2). 1-348. Amsterdam, London, New York, Tokyo. Elsevier Science Publishers.

Ministry of Agriculture, Food and Fisheries. 2001. Fast stats: Agriculture and food 2000. http://www.agf.gov.bc.ca.

Ministry of Agriculture, Food and Fisheries. 2002. Census of agriculture 2001 and historical comparisons -BC summary. Statistics Canada. http://www.agf.gov.bc.ca/stats/2001census.pdf

Ministry of Forest. 2001. Tree farm licence (TFL) location map. http://www.for.gov.bc.ca.

Ministry of Forests. 2002. British Columbia Ministry of Forest 2001/02 annual report: A new era update. http://www.for.gov.bc.ca/hfd/pubs/docs/mr/annual/ar_2000-01/report.pdf

Ministry of Forests. 2003a. Growing together: Forest management of British Columbia. http://www.gov.bc.ca/for/. http://www.growingtogether.ca/.

Ministry of Forests. 2003b. Sustainable harvesting levels, British Columbia, Canada. www.growingtogether.ca.

Ministry of Management Services. 2003. British Columbia statistics. Government of British Columbia. http://www.bcstats.gov.bc.ca/index.htm 3 A.D.

Ministry of Sustainable Resources Management. 2003. BC ecoregions. http://srmwww.gov.bc.ca/rib/wis/eco/bcecode1.html.

Ministry of Water, Land and Air Protection. CRISP database - Pesticide permits issued by the Ministry of Water, Land and Air Protection to Ministry of Forests, and industrial companies between 1990 and 1999. Cronin, D. 2003a.

Ministry of Water, Land and Air Protection. 2003b. Home page. http://www.gov.bc.ca/wlap/.

Ministry of Water, Land and Air Protection. 2003c. Pesticide use permit No. 107-123-02/03 for Canadian National Railway.

Ministry of Water, Land and Air Protection. 2003d. Pesticide use permit No. 776-001-2003/2004. 1-5

Ministry of Water, Land and Air Protection. 2003e. State of environment reporting. http://wlapwww.gov.bc.ca/soerpt/993contaminants/pesticides.html.

Mitchell, D. G., Chapman, P. M., and Long, T. J. 1987. Acute toxicity of Roundup and Rodeo herbicides to rainbow trout, chinook, and coho salmon. Bulletin of Environmental Contamination and Toxicology **39**: 1028-1035.

Mittelstaedt, M. Environmental inspectors find traces of dioxins in over-the-counter pesticides. 2003. Globe and Mail A5 .

Moore, A. and Waring, C. P. 1996. Sublethal effects of the pesticide diazinon on olfactory function in mature male Atlantic salmon parr. Journal of Fish Biology 48(4), 758-775 .

Morgan, J. D., Vigers, G. A., Farrell, A. P., Janz, D. M., and Manville, J. F. 1991. Acute avoidance reactions and behavioral responses of juvenile rainbow trout (*Oncorhynchus mykiss*) to Garlon 4, Garlon 3A and Vision herbicides. Environmental Toxicology and Chemistry **10**: 73-79.

Muir, D., Riget, F., Cleemann, M., Skaare, J., Kleivane, L., Nakata, H., Dietz, R., Severinsen, T., and Tanabe, S. 2000. Circumpolar trends of PCBs and organochlorine pesticides in the Arctic marine environment inferred from levels in ringed seals. Environmental Science and Technology **34**: 2431-2438.

Muir, D. C. G., Ford, C. A., Grift, N. P., Metner, D. A., and Lockhart, L. 1990. Geographic variation of chlorinated hydrocarbons in burbot (*Lota lota*) from remote lakes and rivers in Canada. Archives of Environmental Contamination and Toxicology **19**: 530-542.

Muir, D. C. G., Ford, C. A., Rosenberg, B., Norstrom, R. J., Simon, M., and Beland, P. 1996. Persistent organochlorines in beluga whales (*Delphinapterus leucas)* from the St. Lawrence River estuary-I. Concentrations and patterns of specific PCBs, chlorinated pesticides and polychlorinated dibenzo-*p*-dioxins and dibenzofurans. Environmental Pollution **93**: 219-234.

National Forestry Database. 2002. Application of forest herbicides by product in terms of rate and amount of herbicide, 1990-2001. Report No. 9.1.2.1. http://nfdp.ccfm.org/.

Nener, J. C. and Wernick, B. G. 1997. Fraser River Basin strategic water quality plan: Lower Fraser River. Water Quality Series 02. Fraser River Action Plan. Vancouver, BC.

Nener, J. C. and Wernick, B. G. 1998a. Fraser River Basin strategic water quality plan: Chilcotin Region. Water Quality Series 03. Fraser River Action Plan. Vancouver, BC.

Nener, J. C. and Wernick, B. G. 1998b. Fraser River Basin strategic water quality plan: Thompson River Sub-basin. Water Quality Series 02. Fraser River Action Plan. Vancouver, BC.

Nener, J. C. and Wernick, B. G. 2000. Fraser River Basin strategic water quality plan: Middle & North Fraser region. Water Quality Series 04. Fraser River Action Plan. Vancouver, BC.

Norecol Environmental Consultants Ltd. 1993. A comprehensive survey of pesticide use in British Columbia: 1991. 93-3. Environment Canada and Ministry of Environment, Lands, and Parks.

Norris, L. A., Lorz, H. W., and Gregory, S. V. 1983. Influence of forest and rangeland management on anadromous fish habitat in western North Amercia. General Technical Report PNW-149. Pacific Northwest Forest; USDA Forest Service.

Northwest Coalition for Alternatives to Pesticides (NCAP). 1998. Worst kept secrets: Toxic inert ingredients in pesticides. Eugene, OR.

PAN -UK 1996. Organophosphate insecticides. Pesticides News **34**: 20-21.

PAN -UK and Lyons, G. 1999. Fact sheet: Endocrine disrupting pesticides. Pesticides News **46**: 16-19.

Partnership for Pesticide Bylaws. 2002. Pesticides used in our communites - Human health and environmental impacts. http://www.cprontario.org/Impacts.pdf

Pearce, P. A., Elliott, J. E., and Peakall, D. B. 1989. Organochlorine contaminants in eggs of seabirds in the northwest Atlantic, 1968-1984. Environmental Pollution **56**: 217.

Provincial Agricultural Land Commission. 2003a. Map of agricultural land reserve in British Columbia. http://www.alc.gov.bc.ca/alr/ALR_Map.htm.

Provincial Agricultural Land Commission. 2003b. Map of FLR in BC. http://apps.icompasscanada.com/lrc/flr/FLR_Map.stm.

Renner, R. 2002. Evidence that perfluorinated surfactants bioaccumulate. Environmental Science & Technology News **36**: 54A-55A.

Rogers, I. H. and Hall, K. J. 1987. Chlorophenols and chlorinated hydrocarbons in starry flounder (*Platichthys stellatus*) and contaminants in estuarine sediments near a large municipal outfall. Water Pollution Research Journal of Canada **22**: 197-210.

Ross, P. S., Ellis, G. M., Ikonomou, M. G., Barrett-Lennard, L. G., and Addison, R. F. 2000. High PCB concentrations in free-ranging Pacific killer whales, *Orcinus orca*: Effects of age, sex and dietary preference. Marine Pollution Bulletin **40**: 504-515.

Ross, P. S., Jeffries, S. J., Yunker, M. B., Addison, R. F., Ikonomou, M. G., and Calambokidis, J. 2004. Harbour seals (*Phoca vitulina*) in British Columbia, Canada, and Washington, USA, reveal a combination of local and global polychlorinated biphenyl, dioxin, and furan signals. Environmental Toxicology and Chemistry **23**: 157-165.

Sanders, H. O., Finley, M. T., and Hunn, J. B. 1983. Acute toxicity of six forest insecticides to three aquatic invertebrates and four fishes. Technical paper 110. US Department of the Interior Fish and Wildlife Service.

Schaefer, A. 2000. Environmental concerns linked to railroad creosote. Environmental Science & Technology News **34**: 502.

Scholz, N. L., Truelove, N. K., French, B. L., Berejikian, B. A., Quinn, T. P., Casillas, E., and Collier, T. K. 2000. Diazinon disrupts antipredator and homing behaviors in chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Science **57:** 1911-1918.

Servos, M. R. 1999. Review of the aquatic toxicity, estrogenic responses and bioaccumulation of alkylphenols and alkylphenol polyethoxylates. Water Quality Research Journal of Canada **34**: 123-177.

Simms, W., Jeffries, S. J., Ikonomou, M. G., and Ross, P. S. 2000. Contaminant-related disruption of vitamin A dynamics in free-ranging harbor seal (*Phoca vitulina*) pups from British Columbia, Canada and Washington State, USA. Environmental Toxicology and Chemistry **19(11)**: 2844-2849.

Smith, G. J. 1987. Pesticide use and toxicology in relation to wildlife: Organophosphorus and carbamate compounds. Resource Publication 170. United States Department of the Interior Fish and Wildlife Service. Washington, D.C.

Standing Committee on Environment and Sustainable Development. 2000. Pesticides: Making the right choice for the protection of health and the environment. Ottawa, Ontario.

Statistics Canada. 2001. Census of agriculture 2001: Data tables. http://www.statcan.ca/english/freepub/95F0301XIE/tables.htm#crops.

Statistics Canada. 2003. Population statistics. http://www.statcan.ca/.

Stout, V. F. 1986. What is happening to PCBs? Elements of environmental monitoring as illustrated by an analysis of PCB trends in terrestrial and aquatic organisms. *In* Waid, J. S. (*eds.*). PCBs and the Environment, Vol. 1. CRC Press, Boca Raton, Florida. 163-206.

Symons, P. E. K. 1973. Behavior of young Atlantic salmon (*Salmo salar*) exposed to force-fed Fenitrothion, an organophosphate insecticide. Journal of Fisheries Research Board of Canada **30**: 651-655.

Szeto, S. Y., Wan, M. T., Price, P, and Roland, J 1990. Distribution and persistence of diazinon in a cranberry bog. Journal of Agricultural Food Chemistry **38**: 281-285.

Tanabe, S. and Tatsukawa, R. 1991. Persistent organochlorines in marine mammals. Organic Contaminants in the Environment 289.

Tomlin, C. 2000. The pesticide manual. A world compendium, crop protection publication. The Royal Society of Chemistry.

UMA Environmental. 1996. Inventory of golf courses in the Fraser River basin. DOE FRAP 1996-25. UMA Environmental. Burnaby, BC. http://www.rem.sfu.ca/frap/9625.pdf.

United States Environmental Protection Agency. 2001. Lists of other (inert) pesticide ingredients. USEPA office of pesticide programs. http://www.epa.gov/.

United States Environmental Protection Agency. Methyl isothiocyanate (MITC) - Wood preservative. 2003. http://www.epa.gov/pesticides/factsheets/chemicals/methylf.htm.

United States Geological Survey. 1992. Pesticides in stream sediment and aquatic biota. Fact sheet 092-00.

United States Geological Survey. 1995. Pesticides in the atmosphere. FS-152-95. http://ca.water.usgs.gov/pnsp/atmos/.

United States Geological Survey. 2001. Selected findings and current perspectives on urban and agricultural water quality by the national water-quality assessment program (NAWQA). FS-047-01. http://water.usgs.gov/pubs/FS/fs-047-01/.

Vermeer, K., Cretney, W. J., Elliott, J. E., Norstrom, R. J., and Whitehead, P. E. 1993. Elevated polychlorinated dibenzodioxin and dibenzofuran concentrations in grebes, ducks, and their prey near Port Alberni, British Columbia, Canada. Marine Pollution Bulletin **26**: 431-435.

Wan, M. Personal Communications. Pesticides of concern. 2003.

Wan, M. T. 1983. Environmental monitoring studies of selected pesticides spray operations in British Columbia. EP Regional Program Report (Pacific Region). 83-01. Environment Canada. http://www.pyr.ec.gc.ca/EN/Pesticides/english/Publication_1_e.htm

Wan, M. T. 1989. Levels of selected pesticides in farm ditches leading to rivers in the Lower Mainland of British Columbia. Journal of Environmental Science and Health **24**: 183-203.

Wan, M. T. 1991. Railway right-of-way contaminants in the Lower Mainland of British Columbia: Polycyclic aromatic hydrocarbons. Journal of Environmental Quality **20**: 228-234.

Wan, M. T. 1992. Utility and railway right-of-way contaminants in British Columbia: Chlorophenols. Journal of Environmental Quality **21**: 225-231.

Wan, M. T. 1994. Utility right-of-way contaminants: Polycyclic aromatic hydrocarbons. Journal of Environmental Quality **23**: 1297-1304.

Wan, M. T. and Oostdam, J. V 1995. Utility and railway rights-of-way contaminants: Dioxins and furans. Journal of Environmental Quality **24**: 257-265.

Wan, M. T., Szeto, S. Y., and Price, P 1994. Organophosphorus insecticide residues in farm ditches of the Lower Fraser of British Columbia. Journal of Environmental Science and Health **29**: 917-949.

Wan, M. T., Szeto, S. Y., and Price, P 1995. Distribution of endosulfan residues in the drainage waterways of the Lower Fraser Valley of British Columbia. Journal of Environmental Science and Health **30**: 401-433.

Wan, M. T., Watts, R. G., and Moul, D. J. 1987. Toxicity to salmonids of the herbicide glyphosate (Roundup) and its surfactant (MON 0818). EP Regional Program Report (Pacific Region). Environment Canada. http://www.pyr.ec.gc.ca/EN/Pesticides/english/Publication_1_e.htm

Wan, M. T., Watts, R. G., and Moul, D. J. 1989. Effects of different dilution water types on the acute toxicity to juvenile Pacific salmonids and rainbow trout of glyphosate and its fomulated products. Bulletin of Environmental Contamination and Toxicology **43**: 378-385.

Wan, M. T., Watts, R. G., and Moul, D. J. 1991. Acute toxicity to juvenile Pacific northwest salmonids of basacid blue NB755 and its mixture with formulated products of 2,4-D, glyphosate, and triclopyr. Bulletin of Environmental Contamination and Toxicology **47**: 471-478.

Warhurst, A. M. 1995. An environmental assessment of alkylphenol ethoxylates and alkylphenols. Friends of the Earth Scotland, Friends of the Earth. Bonnington Mill, Edinburgh. http://www.foe.co.uk/resource/reports/ethoxylates_alkylphenols.pdf

Waring, C. P. and Moore, A. 1997. Sublethal effects of a carbamate pesticide on pheromonal mediated endocrine function in mature male Atlantic salmon (*Salmo salar*) parr. Fish Physiology and Biochemistry **17**: 203-211.

Weiss, C. M. 1961. Physiological effect of organic phosphorus insecticides on several species of fish. Transactions of the American Fisheries Society **90**: 143-152.

Welch, C. Pesticides restricted to protect salmon; West Coast ruling is sweeping. 2004. Seattle Times Seattle, Washington The Seattle Times Company.

Werring, J. Personal Communications. Pesticide research. 2003.

White, R. C. 1986. Inventory of pesticide use in the Yukon, 1986.

Wilkening, K. E., Barrie, L. A., and Engle, M. 2000. Trans-pacific air pollution. Science **290:** 65-67.

World Wildlife Fund Canada. 1999. Endocrine disrupting pesticides. Briefing.

Yukon Department of Environment. 2002. Yukon state of the environment interim report 2001: An update of environmental indicators. http://www.environmentyukon.gov.yk.ca/soe/soe.shtml.

Yukon Department of Renewable Resources. 2000. Yukon State of the Environment Report 1999. Department of Renewable Resources. http://www.environmentyukon.gov.yk.ca/epa/soe.shtml.

Yukon Executive Council Office. 2000. Yukon fact sheet 2000. http://www.gov.yk.ca/facts/.

Yunker, M. B. and Cretney, J. 1995. Chlorinated dioxin trends between 1987 and 1993 for samples of crab hepatopancreas from pulp and paper mill and harbour sites in British Columbia. Canadian Technical Report of Fisheries and Aquatic Sciences. (2082).

Yunker, M. B., Macdonald, R. W., Goyette, D., Paton, D. W., Fowler, B. R., Sullivan, D., and Boyd, J. 1999. Natural and anthropogenic inputs of hydrocarbons to the Strait of Georgia. Science of the Total Environment **225:** 181-209.

Zinkl, J. G., Shea, P. J., Nakamoto, R. J., and Callman, J. 1987. Brain cholinesterase activity of rainbow trout poisoned by carbaryl. Bulletin of Environmental Contamination and Toxicology **38**: 29-35.

APPENDIX A
ESTIMATED QUANTITIES OF PESTICIDES SOLD IN THE YUKON TERRITORY

Table 25: Estimated quantities of pesticides sold or used in the Yukon in 1994 (Hall *et al.* 1995). Data was based on both actual records from vendors with records and estimates from vendors without records.

Active Ingredient	Quantity (kg) *Sold*	Quantity (kg) *Used*	Type
2,4-D	45.4560	0.1425	herbicide
alkanolamine salts of fatty acids	0.2530		insecticide
allethrin	0.0030	0.0012	insecticide
ammonia soaps	0.0240		repellent
asphalt	0.4850		insecticide
Bacillus thuringiensis israelensis		8828.0000	insecticide
benzyidiethyl	0.0090		repellent
borax	0.0680		insecticide
brodifacoum		0.0001	rodenticide
bromacil	0.4340		herbicide
bromadiolone		0.2721	rodenticide
chlorpyrifos	1.0480	0.0005	insecticide
copper naphthenate	3.9600		wood preservative
creosote	683.5860	6.0	wood preservative
diazinon	0.6520	0.6642	insecticide
dicamba	4.5280		herbicide
dimethoate	0.2090	0.0720	insecticide
diphacinone		0.0065	rodenticide
fatty acids	0.6000		herbicide
glyphosate	6.0970	7.1347	herbicide
lemon grass	0.1920		repellent
malathion	0.1880	22.7360	insecticide
mecoprop	24.2010		herbicide
methyl ammoniumsaccharide	0.0020		repellent
methyl nonyl ketone	0.1840		repellent
mineral oil	1.2130		insecticide
mustard oil	0.0080		repellent
naphthalene	0.0020		repellent
oxine benzoate	0.0030		fungicide
piperonyl butoxide	0.2330		insecticide
potassium salts of fatty acids	0.3650		insecticide
pyrethrin	0.0800	0.0062	insecticide
resmethrin	0.4800		insecticide
rotenone		2.2150	piscicide
silicon dioxide	0.0010		insecticide
soap	0.0860		insecticide
sulphur suphide	0.4600		fungicide
thiram	0.6000		repellent
triclopyr		0.0960	herbicide
zinc naphthenate	2.0600		wood preservative

Bacillus thuringiensis israelensis was used the most with the majority aerially sprayed and to a much lesser extent ground based applications (Hall *et al.* 1995).

APPENDIX B
PESTICIDE USE BY THE FORESTRY SECTOR IN BC

Table 26: Herbicides used by the BC forestry sector: total area (ha), average rate of application (kg/ha), and total amount applied (kg) from 1990-2001(National Forestry Database 2002).

Note: u = unknown: figures are not available but are known to be very small relative to the total for the province
U = unknown: figures are not available but are known to be large relative to the total for the province
* = The amount of insecticide applied may not equal total area treated multiplied by rate if there were multiple applications at one site or if there was insecticide left over after treatments were applied
** = estimated by provincial forestry agency
a.i. = active ingredient

Herbicide Product	Year	Total Land Area (Ha)	Average Rate (a.i. in kg/ha)	Total Herbicide Applied (a.i. in kg)*
Glyphosate	1990	u	u	u
	1991	u	u	u
	1992	35006	1.6	54493
	1993	27378	1.54	49760
	1994	28410	1.52	43300
	1995	18536	1.54	28603
	1996	29830	1.7	50986
	1997	23550	1.58	37233
	1998	16330	6	26256
	1999	U	1.4**	28480**
	2000	U	1.4**	28480**
	2001	U	U	U
2,4-D	1990	u	u	u
	1991	u	u	u
	1992	124	2.2	267
	1993	143	1.25	179
	1994	55	1.73	95
	1995	87	1.26	110
	1996	60	4.16	246
	1997	2	0.87	2
	1998	0	0	0
	1999	0	0	0
	2000	0	0	0
	2001	U	U	U
Hexazinone	2001	U	U	U
Simazine	2001	U	U	U

Table 26: Continued…

Herbicides Product	Yea r	Total Land Area (Ha)	Average Rate (a.i. in kg/ha)	Total Herbicide Applied (a.i. in kg)*
Triclopyr	1990	0	0	0
	1991	u	u	u
	1992	416	0.9	393
	1993	756	0.91	688
	1994	680	1.17	800
	1995	1810	1.22	2201
	1996	1600	1.43	2283
	1997	2620	1.73	4544
	1998	3016	2.8	8459
	1999	U	2.8**	u
	2000	U	2.8**	u
	2001	U	U	U
Amitrol	2001	U	U	U
Picloram	1990	u	u	u
	1991	u	u	u
	1992	0	0	0
	1993	0	0	0
	1994	235	0.68	160
	1995	35	0.74	26
	1996	150	0.95	142
	1997	420	0.87	364
	1998	45	0.51	23
	1999	u	u	u
	2000	u	u	u
	2001	U	U	U
MSMA	2001	U	U	U
Other	1990	0	0	0
	1991	0	0	0
	1992	0	0	0
	1993	0	0	0
	1994	0	0	0
	1995	1	1.43	1
	1996	0	0	0
	1997	0	0	0
	1998	0	0	0
	1999	0	0	0
	2000	0	0	0
	2001	U	U	U

Table 27: Herbicide active ingredient and percent average of the application method used from 1990 to 2001 (National Forestry Database 2002).

Herbicide Product	Application Method	Percent
Glyphosate	Fixed wing aircraft	5.8%
	Helicopter	75.2%
	Ground	19.0%
2,4-D	Helicopter	0.6%
	Ground	99.4%
Hexazinone	Unknown	
Simazine	Unknown	
Triclopyr	Helicopter	4.7%
	Ground	95.3%
Amitrol	Unknown	
Picloram	Ground	100.0%
MSMA	Unknown	
Other	Ground	100.0%

Table 28: Insecticides used by the BC forest sector, total area (ha), average rate of application (kg/ha), and total amount applied (kg) from 1990-2001 (National Forestry Database 2002).

Note: u = unknown: figures are not available but are known to be very small relative to the total for the province
U = unknown: figures are not available but are known to be large relative to the total for the province
a.i. = active ingredient
BIU = Billion (1089) international units
PIB = 20 x 1089 polyhedral inclusion bodies per gram

Insecticide Product	Year	Total Land Area (Ha)	Rate (a.i. in kg/ha, BIU/ha or PIB/ha)	Total Insecticide Applied (a.i. in kg, BIU or PIB)
BT	1990	360	n/a	n/a
	1991	3733	n/a	n/a
	1992	37467	30 BIU/ha	1138417 BIU
	1993	34101	30 BIU/ha	1023030 BIU
	1994	20916	30 BIU/ha	627480 BIU
	1995	0	0	0
	1996	989	30 BIU/ha	30150 BIU
	1997	5400	21 BIU/ha	114300 BIU
	1998	13000	30.5 BIU/ha	396240 BIU
	1999	8030	50.8 BIU/ha	407980 BIU
	2000	8030	50.8 BIU/ha	407980 kg
	2001	U	U	U
Carbaryl	1990	n/a	n/a	n/a
	1991	n/a	n/a	n/a
	1992	9	2.1 kg/ha	18 kg
	1993	0	0	0
	1994	0	0	0
	1995	0	0	0
	1996	1	18.5 kg/ha	4 kg
	1997	42	2.55 kg/ha	107 kg
	1998	0	0	0
	1999	0	0	0
	2000	0	0	0
	2001	U	U	U
Fenitrothion and BT (application #1 & 2)	1990	n/a	n/a	n/a
	1991	n/a	n/a	n/a
	1992	0	0	0
	1993	0	0	0
	1994	0	0	0
	1995	0	0	0
	1996	0	0	0
	1997	0	0	0
	1998	0	0	0
	1999	0	50.8 BIU/ha	660400 BIU
	2000	0	50.8 BIU/ha	660400 BIU
	2001	U	50.8 BIU/ha	660400 BIU

Table 28: Continued…

Insecticide Product	Year	Total Land Area (Ha)	Rate (a.i. in kg/ha, BIU/ha or PIB/ha)	Total Insecticide Applied (a.i. in kg, BIU or PIB)
MSMA	1990	n/a	n/a	n/a
	1991	n/a	n/a	n/a
	1992	914	1.00 kg/ha	929 kg
	1993	332	1.67 kg/ha	555 kg
	1994	147	4.88 kg/ha	716 kg
	1995	225	2.85 kg/ha	640 kg
	1996	56	8.07 kg/ha	452 kg
	1997	84	4.35 kg/ha	366 kg
	1998	12	7.00 kg/ha	225 kg
	1999	0	0	0
	2000	0	0	0
	2001	U	U	U
Nuclear polyhedrosis virus	1990	n/a	n/a	n/a
	1991	n/a	n/a	n/a
	1992	650	0.0125 PIB/ha	8 PIB
	1993	265	0.0090 PIB/ha	2 PIB
	1994	0	0	0
	1995	0	0	0
	1996	0	0	0
	1997	0	0	0
	1998	0	0	0
	1999	0	0	0
	2000	0	0	0
	2001	U	U	U
Other Insecticides	1990	57	n/a	n/a
	1991	203	n/a	n/a
	1992	0	0	0
	1993	0	0	0
	1994	0	0	0
	1995	0	0	0
	1996	0	0	0
	1997	0	0	0
	1998	0	0	0
	1999	13000	n/a	n/a
	2000	13000	n/a	n/a
	2001	U	n/a	n/a

Table 29: Pest associated insecticide active ingredient and percent average of the application method used from 1990 to 2001 (National Forestry Database 2002).

Insect Pest	Insecticide Product	Application Method	Percent
Spruce budworm	BT	Fixed-wing aircraft	28.5%
		Helicopter	68.5%
		Ground	3.0%
	Carbaryl	Ground	100.0%
	Fenitrothion	Unknown	
	Fenitrothion and BT	Unknown	
	Tebufenozide	Unknown	
Jack pine budworm	BT	Unknown	
Mountain pine beetle	MSMA	Ground	100.0%
Hemlock lopper	BT	Unknown	
	Fenitrothion	Unknown	
Douglas-fir tussock moth	Nuclear polyhedrosis virus	Helicopter	100.0%
Other	Other	Helicopter	99.0%
		Unknown	1.0%

APPENDIX C
FORESTRY PESTICIDE USE BY REGION

Table 30: Total pesticides (kg) applied by region, by year, for all sub-categories*, and all methods of application (BC MWLAP 2003a).

Year	Vancouver Island	Lower Mainland	Southern Interior	Kootenay	Cariboo	Skeena	Omineca	Peace
1990	5908	4644	6550	1922	9298	9255	15677	34614
1991	4369	4143	10926	3537	4499	4258	20351	19160
1992	2627	6935	25644	1461	7119	3866	15946	17159
1993	3719	2589	36155	1663	5944	888	20482	15228
1994	2181	3860	28874	2293	7439	530	15153	14782
1995	2724	2976	2384	1040	3308	858	12008	9728
1996	2501	4622	3979	1728	7863	1494	16154	19121
1997	2539	5319	15865	2693	3285	586	10789	16345
1998	2550	4775	33996	7343	907	1572	13112	6582
1999	3239	3881	21111	1947	693	1761	4830	2844

*Sub-categories include forestry health protection, vegetation management, rangeland management, noxious weed control, and rights-of-way.

Table 31: Vancouver Island region – Forestry pesticide use from 1990 to 1999 in all subcategories. Proportion of pesticide (by application) used each year is shown as percent of total (BC MWLAP 2003a).

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1990	ground	2,4-D AMINE	988.1	16.7	1027.8
		ACEPHATE	0.0	0.0	0.1
		GLYPHOSATE	3141.8	53.2	4446.6
		TRICLOPYR	0.1	0.0	0.1
	aerial	BACILLUS THURINGIENSIS	900.0	15.2	360.0
		GLYPHOSATE	878.3	14.9	839.9
1991	ground	2,4-D AMINE	512.0	12.3	279.8
		GLYPHOSATE	3104.2	74.3	5090.1
		SODIUM METABORATE TETRAHYDRATE	50.0	1.2	0.5
		TRICLOPYR	67.1	1.6	125.1
	aerial	GLYPHOSATE	444.6	10.6	664.0
1992	ground	2,4-D AMINE	266.8	10.2	123.8
		GLYPHOSATE	1719.2	65.4	3241.3
		MYCLOBUTANIL	3.0	0.1	5.0
		TRICLOPYR	12.5	0.5	24.0
	aerial	GLYPHOSATE	625.3	23.8	442.6
1993	ground	2,4-D AMINE	179.0	4.8	133.1
		GLYPHOSATE	1608.7	43.3	3045.4
		TRICLOPYR	238.3	6.4	328.2
	aerial	GLYPHOSATE	1567.6	42.2	643.2
		TRICLOPYR	125.3	3.4	170.4
1994	ground	2,4-D AMINE	8.2	0.4	5.5
		AZADIRACHTIN	0.0	0.0	0.2
		GLYPHOSATE	1153.8	52.9	1276.8
		TRICLOPYR	37.7	1.7	73.3
	aerial	GLYPHOSATE	810.5	37.2	1276.8
		TRICLOPYR	170.7	7.8	10.1
1995	ground	2,4-D ESTER	16.9	0.6	10.7
		AZADIRACHTIN	0.0	0.0	0.0
		GLYPHOSATE	1918.2	70.4	2385.7
		PIRIMICARB	0.0	0.0	0.0
		TRICLOPYR	265.9	9.8	498.4
	aerial	GLYPHOSATE	411.4	15.1	555.0
		TRICLOPYR	111.1	4.1	59.2
1996	ground	2,4-D AMINE	8.0	0.3	4.0
		GLYPHOSATE	1077.1	43.1	1955.7
		TRICLOPYR	540.2	21.6	744.0
	aerial	GLYPHOSATE	577.8	23.1	892.5
		TRICLOPYR	297.6	11.9	59.6
1997	ground	2,4-D AMINE	1.2	0.0	1.0
		GLYPHOSATE	1043.5	41.1	1598.5
		TRICLOPYR	729.6	28.7	974.6
	aerial	GLYPHOSATE	462.6	18.2	351.4
		TRICLOPYR	301.9	11.9	90.4
1998	ground	GLYPHOSATE	1161.4	45.5	1562.8
		MECOPROP (POTASSIUM SALTS)	0.4	0.0	0.1
		SI-88-C	0.9	0.0	0.8
		TRICLOPYR	816.2	32.0	665.8
	aerial	GLYPHOSATE	479.3	18.8	464.1
		TRICLOPYR	92.2	3.6	16.5
1999	ground	GLYPHOSATE	1225.5	37.8	1280.8
		TRICLOPYR	1691.2	52.2	1072.8
	aerial	GLYPHOSATE	288.2	8.9	688.7
		TRICLOPYR	34.1	1.1	71.7

Table 32: Lower Mainland region – Forestry pesticide use from 1990 to 1999 in all subcategories. Proportion of pesticide (by application) used each year is shown as percent of total (BC MWLAP 2003a).

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1990	ground	2,4-D ESTER	88.4	1.9	24.0
		GLYPHOSATE	425.7	9.2	258.2
		MONOSODIUM METHANEARSONATE	5.4	0.1	1.3
		PICLORAM	0.0	0.0	0.0
	aerial	GLYPHOSATE	4125.0	88.8	2537.8
1991	ground	MONOSODIUM METHANEARSONATE	0.0	0.0	2.0
		GLYPHOSATE	711.0	17.2	409.6
	aerial	GLYPHOSATE	3432.2	82.8	2273.6
1992	ground	GLYPHOSATE	390.3	5.7	219.0
		MONOSODIUM METHANEARSONATE	5.4	0.1	2.3
		TRICLOPYR	137.8	2.0	152.2
	aerial	GLYPHOSATE	6041.4	88.8	3542.9
		TRICLOPYR	228.5	3.4	224.3
1993	ground	2,4-D AMINE	0.5	0.0	10.0
		GLYPHOSATE	116.8	4.5	115.4
		MONOSODIUM METHANEARSONATE	12.2	0.5	3.0
		TRICLOPYR	108.4	4.2	121.2
	aerial	GLYPHOSATE	2147.2	82.9	1371.9
		HEXYTHIAZOX	16.4	0.6	11.6
		TRICLOPYR	187.0	7.2	112.5
1994	ground	GLYPHOSATE	306.8	7.9	249.5
		TRICLOPYR	68.3	1.8	36.2
	aerial	GLYPHOSATE	3051.9	79.1	2078.5
		TRICLOPYR	433.2	11.2	518.7
1995	ground	2,4-D AMINE	88.8	3.0	72.5
		GLYPHOSATE	88.0	3.0	130.8
		TRICLOPYR	269.7	9.1	348.9
	aerial	2,4-D AMINE	3.3	0.1	2.8
		GLYPHOSATE	1911.7	64.2	1122.1
		TRICLOPYR	614.4	20.6	434.4
1996	ground	GLYPHOSATE	426.2	9.3	207.9
		TRICLOPYR	743.0	16.2	389.8
	aerial	GLYPHOSATE	3134.9	68.5	1771.4
		TRICLOPYR	272.9	6.0	154.3
1997	ground	GLYPHOSATE	873.9	16.4	548.9
		TRICLOPYR	769.7	14.5	740.0
	aerial	GLYPHOSATE	3481.2	65.5	2313.5
		TRICLOPYR	193.8	3.6	110.3
1998	ground	GLYPHOSATE	515.4	10.8	397.3
		TRICLOPYR	1314.3	27.5	880.1
	aerial	GLYPHOSATE	2510.9	52.6	1252.5
		TRICLOPYR	434.1	9.1	287.1
1999	ground	1,3-DICHLOROPROPENE	8.7	0.2	4.0
		2,4-D AMINE	36.4	0.9	11.0
		DICAMBA	11.8	0.3	14.0
		GLYPHOSATE	575.2	14.8	524.6
		TRICLOPYR	1670.2	43.0	1704.8
	aerial	GLYPHOSATE	1316.5	33.9	835.4
		TRICLOPYR	261.9	6.7	106.5

Table 33: Southern Interior region – Forestry pesticide use from 1990 to 1999 in all subcategories. Proportion of pesticide (by application) used each year is shown as percent of total (BC MWLAP 2003a).

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1990	aerial	GLYPHOSATE	927.91	14.17	429.50
		MCH BEAD	70.00	1.07	16.00
		VERBENONE	29.44	0.45	36.00
	ground	2,4-D AMINE	4.70	0.07	3.00
		CHLORPYRIFOS	49.44	0.75	0.76
		GLYPHOSATE	1479.43	22.59	1340.47
		MONOSODIUM METHANEARSONATE	217.86	3.33	56.25
		PICLORAM	3770.84	57.57	6744.77
		PIRIMICARB	0.09	0.00	0.01
1991	aerial	BACILLUS THURINGIENSIS	7302.00	66.83	3180.00
		GLYPHOSATE	761.98	6.97	303.71
		NUCLEAR POLYHEDROSIS VIRUS DOUG. FIR TUSSOC	2.18	0.02	200.00
		VERBENONE	1.78	0.02	0.00
	ground	2,4-D AMINE	4.80	0.04	10.00
		CARBARYL	4.82	0.04	1.44
		GLYPHOSATE	1681.83	15.39	1635.56
		MONOSODIUM METHANEARSONATE	806.62	7.38	1029.98
		PICLORAM	352.28	3.22	574.20
		TRICLOPYR	0.01	0.00	0.01
		VERBENONE	7.46	0.07	87.93
1992	aerial	BACILLUS THURINGIENSIS	22192.00	86.54	36291.00
		GLYPHOSATE	354.59	1.38	199.00
		NUCLEAR POLYHEDROSIS VIRUS DOUG. FIR TUSSOC	8.13	0.03	650.00
		Z-6-HEN-11	0.86	0.00	12.00
	ground	2,4-D AMINE	9.40	0.04	7.30
		AZADIRACHTIN	0.30	0.00	1.00
		CARBARYL	6.50	0.03	1.25
		GLYPHOSATE	2026.54	7.90	1206.44
		METHAMIDOPHOS	0.40	0.00	0.50
		MONOSODIUM METHANEARSONATE	742.69	2.90	747.44
		NAPHTHALENEACETIC ACID (FRUITONE N)	3.42	0.01	0.50
		PICLORAM	299.50	1.17	566.99
1993	aerial	BACILLUS THURINGIENSIS	33797.40	96.13	34183.00
		GLYPHOSATE	725.00	2.06	384.65
		NUCLEAR POLYHEDROSIS VIRUS DOUG. FIR TUSSOC	2.41	0.01	265.00
		PICLORAM	63.63	0.18	30.00
		Z-6-HEN-11	0.81	0.00	24.00
	ground	2,4-D AMINE	1.88	0.01	0.75
		CARBARYL	8.64	0.02	0.33
		GLYPHOSATE	59.02	0.17	1861.14
		MONOSODIUM METHANEARSONATE	189.09	0.54	156.90
		PICLORAM	217.47	0.62	408.33
		TRICLOPYR	92.80	0.26	90.20
1994	aerial	BACILLUS THURINGIENSIS	26662.60	92.34	21428.00
		GLYPHOSATE	599.02	2.07	328.35
		PICLORAM	17.64	0.06	22.50
		Z-6-HEN-11	0.01	0.00	2.00
	ground	2,4-D AMINE	4.70	0.02	2.10
		AZADIRACHTIN	0.01	0.00	0.01
		CARBARYL	4.60	0.02	0.20
		GLYPHOSATE	917.73	3.18	797.03
		MONOSODIUM METHANEARSONATE	507.40	1.76	61.91
		PICLORAM	159.64	0.55	308.49
		TRICLOPYR	0.37	0.00	21.70

Table 33: Southern Interior continued…

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1995	aerial	GLYPHOSATE	330.60	13.87	198.50
	ground	2,4-D AMINE	8.73	0.37	4.85
		AZADIRACHTIN	1.00	0.04	1.01
		CARBARYL	6.70	0.28	0.10
		GLYPHOSATE	1046.20	43.88	812.48
		MONOSODIUM METHANEARSONATE	313.34	13.14	30.64
		PICLORAM	392.38	16.46	719.28
		TRICLOPYR	285.48	11.97	75.70
1996	aerial	BACILLUS THURINGIENSIS	2373.60	59.66	989.00
		GLYPHOSATE	99.93	2.51	53.00
		TEBUFENOZIDE	10.90	0.27	157.00
	ground	2,4-D AMINE	6.15	0.15	2.75
		CARBARYL	3.70	0.09	0.20
		GLYPHOSATE	684.65	17.21	549.69
		MONOSODIUM METHANEARSONATE	268.22	6.74	23.03
		PICLORAM	381.83	9.60	524.84
		TRICLOPYR	149.80	3.76	110.55
1997	aerial	BACILLUS THURINGIENSIS	12960.00	81.69	5400.00
	ground	2,4-D AMINE	104.58	0.66	64.94
		CARBARYL	13.30	0.08	1.50
		DICAMBA	22.08	0.14	10.00
		GLYPHOSATE	364.15	2.30	366.99
		MONOSODIUM METHANEARSONATE	271.87	1.71	54.22
		PICLORAM	470.86	2.97	680.70
		TRICLOPYR	1657.82	10.45	440.71
1998	aerial	BACILLUS THURINGIENSIS	31200.00	91.78	13000.00
	ground	CHLORSULFURON	1.56	0.00	13.00
		CLOPYRALID	3.99	0.01	7.07
		DIURON	117.00	0.34	13.00
		GLYPHOSATE	736.47	2.17	469.54
		MONOSODIUM METHANEARSONATE	200.76	0.59	64.61
		PICLORAM	362.51	1.07	501.26
		TRICLOPYR	1373.82	4.04	216.59
1999	aerial	BACILLUS THURINGIENSIS	19274.40	91.30	8031.00
		GLYPHOSATE	87.17	0.41	62.60
	ground	2,4-D AMINE	16.66	0.08	7.35
		2,4-DB ISO-OCTYL ESTER	4.70	0.02	6.00
		CLOPYRALID	16.27	0.08	40.52
		DICAMBA	4.80	0.02	6.00
		GLYPHOSATE	316.09	1.50	267.92
		MONOSODIUM METHANEARSONATE	241.71	1.14	34.96
		PICLORAM	549.23	2.60	640.01
		TRICHLORFON	75.60	0.36	44.00
		TRICLOPYR	524.04	2.48	147.08

Table 34: Kootenay region – Forestry pesticide use from 1990 to 1999 in all subcategories. Proportion of pesticide (by application) used each year is shown as percent of total (BC MWLAP 2003a).

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1990	ground	GLYPHOSATE	90.3	4.7	42.2
		MONOSODIUM METHANEARSONATE	2.7	0.1	33.2
		PICLORAM	113.0	5.9	198.7
	aerial	GLYPHOSATE	1715.8	89.3	808.2
1991	ground	DICAMBA	2.4	0.1	1.0
		GLYPHOSATE	191.1	5.4	92.0
		MONOSODIUM METHANEARSONATE	35.0	1.0	3.2
		PICLORAM	160.3	4.5	206.4
	aerial	GLYPHOSATE	3148.4	89.0	1578.3
1992	ground	DICAMBA	31.5	2.2	16.7
		GLYPHOSATE	63.3	4.3	32.2
		MONOSODIUM METHANEARSONATE	2.0	0.1	0.0
		PICLORAM	160.6	11.0	230.9
	aerial	GLYPHOSATE	1203.6	82.4	606.3
1993	ground	2,4-D AMINE	52.7	3.2	17.6
		DICAMBA	10.9	0.7	4.3
		GLYPHOSATE	88.9	5.3	42.9
		MONOSODIUM METHANEARSONATE	17.8	1.1	4.0
		PICLORAM	123.9	7.5	206.9
	aerial	GLYPHOSATE	1368.6	82.3	731.0
1994	ground	2,4-D AMINE	12.0	0.5	4.0
		DICAMBA	25.6	1.1	9.6
		GLYPHOSATE	48.5	2.1	39.5
		MONOSODIUM METHANEARSONATE	0.2	0.0	0.4
		PICLORAM	108.9	4.7	201.1
		TRICLOPYR	1.7	0.1	0.2
	aerial	GLYPHOSATE	2095.9	91.4	1081.3
1995	ground	2,4-D AMINE	1.1	0.1	0.8
		DICAMBA	21.6	2.1	9.2
		GLYPHOSATE	40.8	3.9	33.2
		PICLORAM	145.6	14.0	267.4
		TRICLOPYR	327.3	31.5	268.4
	aerial	GLYPHOSATE	503.9	48.4	280.6

Table 34: Kootenay region continued…

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1996	ground	CLOPYRALID	0.2	0.0	0.5
		DICAMBA	27.6	1.6	26.2
		GLYPHOSATE	43.5	2.5	39.8
		MONOSODIUM METHANEARSONATE	0.8	0.0	0.1
		PICLORAM	112.8	6.5	205.7
		TRICLOPYR	127.9	7.4	33.3
	aerial	GLYPHOSATE	1286.4	74.4	487.7
		TRICLOPYR	129.1	7.5	101.5
1997	ground	2,4-D AMINE	7.1	0.3	6.9
		DICAMBA	9.0	0.3	10.0
		GLYPHOSATE	1320.9	49.1	907.8
		MONOSODIUM METHANEARSONATE	4.5	0.2	2.1
		PICLORAM	94.8	3.5	154.7
		TRICLOPYR	692.8	25.7	204.0
	aerial	GLYPHOSATE	563.6	20.9	396.4
1998	ground	2,4-D AMINE	281.9	3.8	168.1
		CLOPYRALID	9.0	0.1	40.0
		DICAMBA	20.1	0.3	19.2
		DIURON	239.5	3.3	49.9
		CHLOROTHALONIL	2.4	0.0	7.8
		GLYPHOSATE	487.5	6.6	417.5
		IMAZYPYR	24.0	0.3	49.9
		PICLORAM	221.4	3.0	422.4
		TRICLOPYR	3975.2	54.1	769.5
	aerial	GLYPHOSATE	2043.6	27.8	1032.1
		TRICLOPYR	39.0	0.5	7.0
1999	ground	2,4-D AMINE	187.0	9.6	44.7
		CLOPYRALID	23.9	1.2	87.5
		DICAMBA	11.0	0.6	11.5
		DIURON	142.9	7.3	17.6
		GLYPHOSATE	910.8	46.8	688.5
		HEXAZINONE	8.0	0.4	3.6
		MCH BEAD	0.1	0.0	2.6
		PICLORAM	161.0	8.3	229.8
		TRICLOPYR	423.6	21.8	104.1
	aerial	GLYPHOSATE	78.8	4.0	44.0

Table 35: Cariboo region – Forestry pesticide use from 1990 to 1999 in all subcategories. Proportion of pesticide (by application) used each year is shown as percent of total (BC MWLAP 2003a).

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1990	aerial	GLYPHOSATE	8067.6	86.8	4798.0
	ground	CARBARYL	13.4	0.1	0.8
		GLYPHOSATE	870.8	9.4	670.1
		HEXAZINONE	279.4	3.0	256.5
		MONOSODIUM METHANEARSONATE	5.4	0.1	0.5
		PICLORAM	61.6	0.7	114.3
1991	aerial	GLYPHOSATE	4177.9	92.9	2247.8
	ground	CARBARYL	6.8	0.2	0.4
		GLYPHOSATE	214.4	4.8	139.0
		HEXAZINONE	89.0	2.0	7.4
		MONOSODIUM METHANEARSONATE	1.5	0.0	4.6
		PICLORAM	9.3	0.2	16.7
1992	aerial	GLYPHOSATE	6908.7	97.1	4167.0
	ground	CARBARYL	6.7	0.1	0.4
		GLYPHOSATE	185.4	2.6	118.7
		MONOSODIUM METHANEARSONATE	0.5	0.0	0.3
		PICLORAM	17.3	0.2	27.0
1993	aerial	GLYPHOSATE	5783.7	97.3	3237.8
	ground	GLYPHOSATE	143.9	2.4	129.5
		PICLORAM	16.7	0.3	22.4
1994	aerial	GLYPHOSATE	6750.0	90.7	3669.7
		TRICLOPYR	2.4	0.0	0.7
	ground	GLYPHOSATE	664.6	8.9	542.5
		PICLORAM	21.7	0.3	26.4
1995	aerial	GLYPHOSATE	3044.4	92.0	1740.2
		TRICLOPYR	49.9	1.5	14.7
	ground	GLYPHOSATE	193.1	5.8	169.5
		PICLORAM	20.4	0.6	30.1
1996	aerial	GLYPHOSATE	7819.1	99.4	4448.2
	ground	GLYPHOSATE	26.3	0.3	18.3
		PICLORAM	17.4	0.2	21.9
1997	aerial	GLYPHOSATE	3239.5	98.6	1862.1
	ground	GLYPHOSATE	11.2	0.3	5.3
		PICLORAM	34.3	1.0	38.2
1998	aerial	GLYPHOSATE	775.8	85.6	486.5
	ground	GLYPHOSATE	83.3	9.2	55.1
		PICLORAM	47.7	5.3	44.0
1999	aerial	GLYPHOSATE	590.4	85.2	412.0
	ground	GLYPHOSATE	95.5	13.8	56.5
		PICLORAM	7.3	1.1	7.6

Table 36: Skeena region – Forestry pesticide use from 1990 to 1999 in all subcategories. Proportion of pesticide (by application) used each year is shown as percent of total (BC MWLAP 2003a).

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1990	ground	GLYPHOSATE	1383.8	15.0	1733.4
		MONOSODIUM METHANEARSONATE	144.3	1.6	22.5
		PICLORAM	25.5	0.3	34.3
	aerial	GLYPHOSATE	7701.4	83.2	4627.9
1991	ground	GLYPHOSATE	602.5	14.2	572.4
		MONOSODIUM METHANEARSONATE	77.6	1.8	58.2
	aerial	GLYPHOSATE	3575.5	84.0	2021.9
1992	ground	GLYPHOSATE	431.2	11.2	293.1
		MONOSODIUM METHANEARSONATE	84.0	2.2	62.3
		PICLORAM	4.8	0.1	1.5
	aerial	GLYPHOSATE	3345.7	86.5	2033.2
1993	ground	DICAMBA	0.3	0.0	0.3
		GLYPHOSATE	2.1	0.2	5.3
		MONOSODIUM METHANEARSONATE	159.1	17.9	97.2
		PICLORAM	3.2	0.4	3.1
		PROPYLTHIETA	0.1	0.0	0.2
	aerial	GLYPHOSATE	723.4	81.4	449.5
1994	ground	DICAMBA	0.1	0.0	0.0
		GLYPHOSATE	64.0	12.1	33.8
		MONOSODIUM METHANEARSONATE	91.2	17.2	11.1
		PICLORAM	0.8	0.2	2.4
	aerial	GLYPHOSATE	374.1	70.5	215.7
1995	ground	DICAMBA	1.9	0.2	0.7
		GLYPHOSATE	648.2	75.5	457.8
		MONOSODIUM METHANEARSONATE	184.4	21.5	36.7
		PICLORAM	4.0	0.5	7.1
	aerial	GLYPHOSATE	19.9	2.3	14.0
1996	ground	GLYPHOSATE	1228.8	82.3	278.6
		MONOSODIUM METHANEARSONATE	120.4	8.1	24.2
	aerial	GLYPHOSATE	144.4	9.7	82.2
1997	ground	DICAMBA	6.7	1.1	3.8
		GLYPHOSATE	512.9	87.5	265.2
		MONOSODIUM METHANEARSONATE	66.5	11.4	22.7
1998	ground	GLYPHOSATE	859.2	54.7	479.2
		MONOSODIUM METHANEARSONATE	109.5	7.0	19.0
		PICLORAM	0.7	0.0	0.6
	aerial	GLYPHOSATE	602.8	38.3	204.3
1999	ground	GLYPHOSATE	1244.6	70.7	694.2
		MONOSODIUM METHANEARSONATE	116.8	6.6	18.5
		PICLORAM	14.0	0.8	13.1
		TRICLOPYR	386.0	21.9	204.9

Table 37: Omincea region – Forestry pesticide use from 1990 to 1999 in all subcategories. Proportion of pesticide (by application) used each year is shown as percent of total (BC MWLAP 2003a).

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1990	aerial	BACILLUS THURINGIENSIS	0.0	0.0	533.0
		GLYPHOSATE	13832.4	88.2	7569.6
		HEXAZINONE	83.7	0.5	27.3
	ground	2,4-D AMINE	0.5	0.0	0.4
		2,4-D ESTER	8.0	0.1	21.3
		ATRAZINE	66.2	0.4	2.9
		DICAMBA	301.0	1.9	26.9
		GLYPHOSATE	1068.1	6.8	1175.1
		MINERAL OIL (HERBICIDAL)	80.0	0.5	0.2
		MONOSODIUM METHANEARSONATE	123.4	0.8	58.2
		PICLORAM	114.3	0.7	112.1
1991	aerial	BACILLUS THURINGIENSIS	2926.0	14.4	553.0
		GLYPHOSATE	16868.6	82.9	9361.8
	ground	2,4-D AMINE	6.0	0.0	1.7
		2,4-D ESTER	30.7	0.2	29.3
		DICAMBA	30.8	0.2	38.1
		GLYPHOSATE	326.5	1.6	191.1
		MONOSODIUM METHANEARSONATE	34.4	0.2	103.4
		PICLORAM	128.3	0.6	193.8
1992	aerial	BACILLUS THURINGIENSIS	3000.0	18.8	570.3
		DIMETHOATE	11.7	0.1	75.0
		GLYPHOSATE	12580.7	78.9	7201.9
	ground	2,4-D AMINE	33.3	0.2	72.0
		DICAMBA	34.3	0.2	84.4
		GLYPHOSATE	107.5	0.7	71.9
		MONOSODIUM METHANEARSONATE	42.2	0.3	32.1
		PICLORAM	135.7	0.9	132.0
1993	aerial	CARBARYL	57.6	0.3	90.0
		DIMETHOATE	45.5	0.2	328.7
		GLYPHOSATE	19958.7	97.4	11150.6
	ground	2,4-D AMINE	25.7	0.1	28.5
		DICAMBA	4.8	0.0	20.7
		GLYPHOSATE	196.5	1.0	140.4
		MONOSODIUM METHANEARSONATE	90.5	0.4	55.7
		PICLORAM	102.9	0.5	148.5
1994	aerial	GLYPHOSATE	13548.8	89.4	7393.0
	ground	2,4-D AMINE	131.3	0.9	82.5
		DICAMBA	30.9	0.2	36.0
		DIURON	995.4	6.6	46.1
		GLYPHOSATE	237.4	1.6	186.0
		MECOPROP (POTASSIUM SALTS)	5.1	0.0	2.3
		MONOSODIUM METHANEARSONATE	85.5	0.6	65.7
		PICLORAM	118.4	0.8	143.6

Table 37: Omineca region continued…

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1995	aerial	GLYPHOSATE	10525.2	87.6	5596.3
	ground	2,4-D AMINE	54.5	0.5	44.4
		CHLORONEB	10.0	0.1	1.1
		DICAMBA	45.6	0.4	74.0
		DIURON	702.9	5.9	32.6
		GLYPHOSATE	319.8	2.7	153.1
		IPRODIONE	1.4	0.0	0.5
		MECOPROP (POTASSIUM SALTS)	16.9	0.1	12.0
		MONOSODIUM METHANEARSONATE	95.5	0.8	16.7
		PICLORAM	199.3	1.7	190.4
		QUINTOZENE	28.6	0.2	1.1
		THIOPHANATE-METHYL	0.9	0.0	0.6
		TRICLOPYR	7.7	0.1	20.0
1996	aerial	GLYPHOSATE	14803.5	91.6	8974.9
	ground	2,4-D AMINE	80.9	0.5	85.0
		DICAMBA	17.3	0.1	81.0
		FATTY ACID	213.2	1.3	10.2
		GLYPHOSATE	798.8	4.9	446.8
		IPRODIONE	3.4	0.0	1.1
		MECOPROP (POTASSIUM SALTS)	33.0	0.2	62.0
		MONOSODIUM METHANEARSONATE	16.8	0.1	2.8
		PICLORAM	133.2	0.8	142.1
		QUINTOZENE	53.8	0.3	1.1
1997	aerial	GLYPHOSATE	9478.3	87.8	5185.2
	ground	2,4-D AMINE	17.0	0.2	22.0
		CLOPYRALID	5.0	0.0	25.2
		DICAMBA	37.5	0.3	54.0
		GLYPHOSATE	1062.6	9.8	618.2
		IPRODIONE	2.8	0.0	1.1
		MONOSODIUM METHANEARSONATE	38.3	0.4	2197.0
		PICLORAM	103.1	1.0	106.5
		QUINTOZENE	42.8	0.4	1.1
		THIOPHANATE-METHYL	1.9	0.0	1.1
1998	aerial	GLYPHOSATE	12443.0	94.9	7265.4
	ground	2,4-D AMINE	2.6	0.0	18.8
		2,4-D ESTER	14.1	0.1	9.4
		CLOPYRALID	8.9	0.1	44.5
		DICAMBA	35.4	0.3	54.9
		GLYPHOSATE	491.1	3.7	402.9
		IPRODIONE	1.2	0.0	1.2
		MECOPROP (POTASSIUM SALTS)	2.7	0.0	18.8
		MONOSODIUM METHANEARSONATE	23.2	0.2	790.9
		PICLORAM	69.2	0.5	103.9
		QUINTOZENE	19.6	0.1	1.2
		THIOPHANATE-METHYL	1.6	0.0	1.2
1999	aerial	GLYPHOSATE	3068.8	63.5	1962.8
	ground	2,4-D AMINE	16.4	0.3	15.7
		CLOPYRALID	2.3	0.0	6.5
		DICAMBA	27.4	0.6	43.7
		GLYPHOSATE	1668.3	34.5	1076.9
		MECOPROP (POTASSIUM SALTS)	8.6	0.2	15.7
		MONOSODIUM METHANEARSONATE	3.0	0.1	295.0
		PICLORAM	34.5	0.7	42.0
		THIOPHANATE-METHYL	1.2	0.0	1.2

Table 38: Peace region – Forestry pesticide use from 1990 to 1999 in all subcategories. Proportion of pesticide (by application) used each year is shown as percent of total (BC MWLAP 2003a).

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1990	aerial	GLYPHOSATE	33078.3	95.6	17034.8
	ground	GLYPHOSATE	1093.8	3.2	1095.2
		HEXAZINONE	14.2	0.0	24.3
		MONOSODIUM METHANEARSONATE	366.2	1.1	259.1
		PICLORAM	61.7	0.2	59.2
1991	aerial	GLYPHOSATE	18300.6	95.5	10222.4
	ground	DIMETHOATE	0.3	0.0	0.2
		GLYPHOSATE	794.8	4.1	450.6
		MINERAL OIL (HERBICIDAL)	9.0	0.0	0.1
		MONOSODIUM METHANEARSONATE	45.9	0.2	83.5
		OXYDEMETON-METHYL	0.3	0.0	0.2
		PICLORAM	8.8	0.0	8.0
1992	aerial	GLYPHOSATE	16843.7	98.3	10636.5
	ground	CARBARYL	4.8	0.0	6.9
		DISODIUM OCTABORATE TETRAHYDRATE	6.0	0.0	0.4
		GLYPHOSATE	218.4	1.3	132.4
		MINERAL OIL (HERBICIDAL)	0.4	0.0	0.2
		MONOSODIUM METHANEARSONATE	52.1	0.3	69.5
		PICLORAM	8.3	0.0	7.4
1993	aerial	GLYPHOSATE	14192.6	93.2	8729.2
	ground	DISODIUM OCTABORATE TETRAHYDRATE	0.7	0.0	2.0
		GLYPHOSATE	49.3	0.3	282.7
		MINERAL OIL (HERBICIDAL)	864.0	5.7	2.0
		MONOSODIUM METHANEARSONATE	86.1	0.6	15.5
		PICLORAM	35.6	0.2	32.9
1994	aerial	GLYPHOSATE	13431.9	90.9	8837.4
		TRICLOPYR	80.7	0.5	20.0
	ground	GLYPHOSATE	303.7	2.1	296.0
		MINERAL OIL (HERBICIDAL)	864.0	5.8	2.0
		MONOSODIUM METHANEARSONATE	61.4	0.4	18.3
		PICLORAM	40.5	0.3	24.6

Table 38: Peace region continued…

Year	Method	Active Ingredient	Amount		
			Quantity (kg)	% of total	Area (ha)
1995	aerial	GLYPHOSATE	9162.2	94.2	5685.7
	ground	DICAMBA	14.2	0.1	13.5
		GLYPHOSATE	84.6	0.9	64.7
		MONOSODIUM METHANEARSONATE	137.6	1.4	23.3
		PICLORAM	51.9	0.5	89.9
		TRICLOPYR	277.2	2.8	110.1
1996	aerial	GLYPHOSATE	18371.0	96.1	9405.8
	ground	2,4-D AMINE	238.5	1.2	55.2
		GLYPHOSATE	374.5	2.0	202.0
		MONOSODIUM METHANEARSONATE	45.7	0.2	5.9
		PICLORAM	91.4	0.5	92.7
1997	aerial	GLYPHOSATE	15007.7	91.8	9345.8
		TRICLOPYR	209.7	1.3	67.6
	ground	CLOPYRALID	9.4	0.1	23.1
		DICAMBA	5.4	0.0	4.5
		DIURON	644.3	3.9	29.8
		GLYPHOSATE	417.3	2.6	284.7
		MONOSODIUM METHANEARSONATE	7.0	0.0	3.3
		PICLORAM	43.8	0.3	71.2
1998	aerial	GLYPHOSATE	5523.7	83.9	3785.6
		TRICLOPYR	24.5	0.4	19.8
	ground	CLOPYRALID	4.6	0.1	14.2
		GLYPHOSATE	628.3	9.5	336.3
		PICLORAM	10.2	0.2	10.0
		TRICLOPYR	390.8	5.9	179.0
1999	aerial	GLYPHOSATE	2022.2	71.1	1311.7
	ground	CLOPYRALID	2.3	0.1	7.9
		GLYPHOSATE	769.1	27.0	434.9
		MANCOZEB	32.8	1.2	19.4
		MYCLOBUTANIL	0.2	0.0	0.9
		PICLORAM	17.3	0.6	16.3
		PROPICONAZOLE	0.2	0.0	0.8

APPENDIX D
CROP PROFILES IN BC

Crop Profile Legend

Percentage of Crop Treated*:

RANKING	SCALE
VH - VERY HIGH	90-100
H - HIGH	75-89
M - MODERATE	50-74
ML - MODERATELY LOW	20-49
L - LOW	5-19
N - NOT SIGNIFICANT	less than 5
0	0
U	unknown

* this does not reflect the actual acres treated. For example, 90% of a 1000 acre crop would mean that 900 acres were treated. However, if 90% of a 10 acre crop was treated it would mean that only 9 acres was treated.

Application Method:

METHOD	ABBREVIATION
BROADCAST	bg
DRENCH	d
DISPENSER (FUMIGANT)	dis
DISPENSER (TWIST TIE)	distwt
FRUIT DIP	fd
FOLIAR SPRAY	fs
GRANULE	g
GROUND SPRAY	gs
HAND SPRAY	hs
IMMERSED CUTTINGS	i
ROOTDIP	rd
SOIL DRENCH	sd
SOIL FUMIGANT	sf
STEM	st
TRUNK SPRAY	ts

The following crop profiles provide information on the pesticides used by growers, rate of application, estimated number of applications per year, application method and timing. Information was compiled by the BC MAFF and was determined through interviews with crop growers.

Table 39: Tree Fruit - Fungicides

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method	Timing/Notes
Cherries (938)	Iprodione	VH	1-4	1.5-1.75kg/ha or 50g/100	fs	from bloom to PHI
Southern Interior:	Myclobutanil	M	1-3	340g/ha	fs	sprayed when in bloom to PHI:
Okanagan, Similkameen,	Propiconazole	M	1-2	500mL/ha	fs	from bloom to PHI
Creston Valley	Sulphur, lime sulphur	M	1-4	10.0L +2.5L dormant oil/200L water	fs	at husk fall, repeated as required
	Benomyl	L	1-2	1lb./100gals.	fs	from bloom to PHI
	Captan*	L	1-3	4.0-4.75kg/ha	fs	from bloom to prior to harvest
	Chlorothalonil*	L	1	5.0-9.0L/ha	fs	from bloom to through harvest
	Triforine	L	1	2.5L/ha	fs	applied before husk-fall
	Thiophanate-methyl	N	1	1.75kg/ha	fs	from bloom to PHI
	Ferbam	0	0	6.75kg/ha	fs	from bloom to PHI
Pears (339)	Sulphur, lime sulphur	VH	1-4	2.5L/200L water	fs	pink
Southern Interior (99%):	Copper	N	1-2	3.75kg/ha	fs	dormant to silver tip
Okanagan and Kootenays	Streptomycin	N	1-3	5.4kg/ha (max)	fs	before bloom
and Vancouver Island (1%)	Thiophanate-methyl	N	1	2.25kg/ha	fs	pink
	Dodine	0	0	2.25-3.25kg/ha	fs	from pre-bloom to first cover
	Dinocap + mancozeb	0	0	6.75kg/ha	fs	throughtout season
	Captan	0	0	4.0kg/ha	fs	pre-bloom, petal-fall, and cover
	Ferbam	0	0	6.75kg/ha	fs	from pink throughout summer
Peaches (568)	Copper	H/VH	1	3.75-4.5kg/ha	fs	post-harvest
Southern Interior (99%):	Sulphur, lime sulphur	H	1-4	2.5-20.0L/200L water	fs or g	throughtout season
Okanagan and Kootenays	Iprodione	M	1-3	1.5-1.75kg/ha or 50g/100	fs	from bloom through harvest
and Vancouver Island (1%)	Myclobutanil	ML	1-2	340g/ha	fs	from bloom through harvest
	Ziram	ML	1	8.0kg/ha	fs	at or before husk-fall
	Triforine	L	1	2.5L/ha	fs	before blossom
	Propiconazole	L	1-2	500ml/ha	fs	from bloom through harvest
	Captan	L	1	4.0-4.75kg/ha	fs	from bloom through harvest
	Cyprodinil	N	1	370-740g/ha	fs	from bloom through harvest
	Benomyl	N	1-2	850g +4.0kg Captan 50W/ha	fs	from bloom through harvest
	Thiophanate-methyl	N	1	1.75kg/ha	fs	from bloom through harvest
	Chlorothalonil	N	1	5.0-9.0L/ha	fs	applied before husk-fall or dormancy depending on disease
	Ferbam	N	1	5.25-8.25kg/ha	fs	during blossom, before husk-fall or at dormancy depending on disease
	Dicloran	N	1	1.75kg/1000L	fs or fd	before harvest or post-harvest
	Agrobacterium radiobacter	0	0	160kg/45kg of seed	I	pre-plant
Apples (7,538)	Myclobutanil	H	1-3	340g/ha	fs	green to tight cluster, pink, petal-fall
Southern Interior (99%):	Sulphur	M/ML	1-5	12-15kg/ha or 22.5kg/ha	fs	green to tight cluster, pink, petal-fall
Okanagan and Kootenays	Metiram	ML	1-4	3.0-6.0kg/ha	fs	green to tight cluster, pink, petal-fall
Vancouver Island & Lower Mainland (1%)	Mancozeb	L	1-4	5.0-6.0kg/ha	fs	green to tight cluster, pink, petal-fall
	Captan	L	1-2	2-4kg/ha	fs	green to tight cluster, pink, petal-fall
	Ziram	L	1	5.0kg/ha	fs	summer
	Kresoxim-methyl	L	1-3	180-450g/ha	fs	green to tight cluster, pink, petal-fall
	Flusilazole	N	1-3	100-200g/ha	fs	green to tight cluster, pink, petal-fall
	Cyprodinil	N	1	190-370g/ha	fs	green to tight cluster, pink, petal-fall
	Benomyl	N	1	550g +3.25kg Manzate 200/ha	fs	green to tight cluster, pink, petal-fall
	Thiophanate-methyl	N	1	2.25kg/ha	fs	green to tight cluster, pink, petal-fall
	Lime sulphur	N	1-2	2.5L/200L water	fs	green to tight cluster, pink, petal-fall
	Ferbam	N	1	2.5-6.75kg/ha	fs	summer
	copper, or copper+lime	N	1	1.95-3.75kg/ha	fs	delayed dormant
	Streptomycin	N	1-3	5.4kg/ha (max)	fs	blossom, or summer
	Metalaxyl-M	N	1	4.25mL/5.0L water per tree	sd	non-bearing trees only
	Fosetyl-aluminum	N	1-2	2.0-5.0kg/ha	fs or sd	blossom, or summer
	Dinocap + mancozeb	0	0	6.75kg/ha	fs	green to tight cluster, pink, petal-fall

Table 40: Tree Fruit - Insecticides

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method	Timing/Notes
Cherries (938)	*Bacillus thuringiensis sp. Kurstaki*	H	1-2	0.25-21lbs /100gal	fs	bloom
Southern Interior:	Carbaryl	H	1	3.1-6.25 L/ha	fs	summer; extremely toxic to fish and wildlife
Okanagan, Similkameen, Creston Valley	Diazinon	H	1-3	0.56-1.4kg/ha in 100gals. Of water	fs	pre-bloom, petal-fall, or post harvest, depending on pest
	Imidacloprid	H	1-2	unknown	fs	
	Dormant oil	M	1	65L/ha	fs	dormant or pre-bloom
	Azinophos-methyl	ML	1-2	varies depending on product	fs	pre-bloom, petal-fall, or summer
	Dimethoate	ML	1	2.25L/ha	fs	summer, post-harvest
	Malathion	ML	1	7.5-12.5kg/ha, 1-2.5L per 1000L water	fs	summer
	Endosulfan	L	1	1.5kg/1000L or 3.25-4.5kg/ha	fs	pre-bloom or summer; very toxic to fish
	Dicofol	L	1	4.50-6.75kg/ha	fs	post-harvest
	Isomate-P	N	1	250 dispensers /ha	dis	prior to moth emergence, in spring
	Phosalone	N	1	2.0-3.0L/ha	fs	summer
Pears (339)	Dormant oil	VH	1-2	65L/ha	fs	dormant
Southern Interior (99%):	Abamectin	M	1	750-1500mL/ha	fs	summer
Okanagan and Kootenays	Phosmet	M	1-3	3.75kg/ha	fs	summer
and Vancouver Island (1%)	Bacillus thuringiensis sp. Kurstaki	ML	1-2	2250-3350g/ha	fs	blossom, petal-fall, summer
	Phosalone	ML	1-3	2.0-3.0L/ha	fs	summer
	Tebufenozide	ML	1-2	1.0L/ha	fs	petal fall and summer
	Endosulfan	L	1	3.25-4.5kg/ha	fs	pre-bloom
	Isomate-C-Plus	N	1	1000dispensers/ha	hs	prior to spring moth emergence
	Azinophos-methyl	N	1	625-775g/1000L	fs	pink, petal-fall, summer
	Dicofol	N	1	3.25-5.0kg/ha	fs	summer
	Pyridaben	N	1	300-720g/ha	fs	summer
	Clofentezine	N	1	300-600mL/h	fs	petal-fall
	Dimethoate	0	0	1.0-1.25L/ha in 1000L water	fs	summer
	Diazinon	0	0	1.0L/1000L water	fs	throughout season
	Malathion	0	0	100mL/100L water	fs	summer
	Chinomethionat	0	0	625g-2.0kg/1000L	fs	pre-bloom, post-harvest
	(Z)-11-tetredeceb-1-yl-acetate	0	0	250-500mL/ha	fs	spring, summer
	Formetanate hydrochloride	0	0	4.48kg/ha	fs	when mites are first noticed
Peaches (568)	Dormant oil	H	1	65L/ha	fs	dormant or pre-bloom
Southern Interior (99%):	Isomate-P	ML	1	625 dispenser/ha	dis/wt	prior to moth emergence, in spring
Okanagan and Kootenays	Endosulfan	ML	1-2	3.25-4.5kg/ha	rd; ts; fs	pre-plant; summer; pink stage through harvest
and Vancouver Island (1%)	Pirimicarb	ML	1	unknown	fs	before husk-fall
	Deltamethrin	ML	1	200mL/ha	fs	pink or petal-fall
	Dicofol	N	1	3.25-4.5kg/ha	fs	summer
	Azinophos-methyl	N	1	625-925g/1000L	fs	when pests are present
	Bacillus thuringiensis sp. Kurstaki	N	1	2250-3350g/ha	fs	pink stage, petal fall
	Phosmet	N	1	3.75kg/ha	fs	pink stage through harvest
	Carbaryl	N	1	6.25L/ha	fs	when pests are present
	Diazinon	N	1	1.0L/1000L water	fs	dormant through ripening
	Lime-sulphur	0	0	20L/200L water	fs	dormant or pink stage
	Formetanate hydrochloride	0	0	1.1kg/ha	fs	summer
	Clofentezine	0	0	300mL/ha	fs	after bloom
	Malathion	0	0	100mL/100L water	fs	after petal-fall

Table 40: Tree Fruit – Insecticides continued…

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method	Timing/Notes
Apples (7,538)	Dormant oil	VH	1	65L/ha	fs	green to tight cluster
Southern Interior (99%):	Azinophos-methyl	H	1-2	625-775g/1000L	fs	pink, petal-fall, summer
Okanagan and Kootenays	Bacillus thuringiensis sp. Kurstaki	H	1-2	560-3350g/ha	fs	blossom, petal-fall, summer
and Vancouver Island and Lower Mainland (1%)	Diazinon	M	1	1.0L/1000L water	fs	pink, petal-fall, summer
	Isomate-C-Plus	M	1	1000dispensers/ha	dis	prior to moth emergence, in spring
	Tebufenozide	ML	1-2	0.5-1.0L/ha	fs	pink, petal-fall, summer
	Endosulfan	ML	1	3.25-4.5kg/ha	fs	petal-fall, summer
	Imidacloprid	ML	1	200-380mL/ha	fs	petal-fall, summer
	phosmet	L	1-2	3.75kg/ha	fs	summer
	Phosalone	L	1-2	2.0-3.0L/ha	fs	summer
	Dimethoate	N	1	1.0-1.25L/ha in 1000L water	fs	summer
	Clofentezine	N	1	300-600mL/h	fs	petal-fall
	Dicofol	N	1	3.25-5.0kg/ha	fs	summer
	Abamectin	N	1	750mL/ha	fs	summer
	Spinosad	N	1-2	300g/ha	fs	petal fall, summer
	Pyridaben	N	1	300-720g/ha	fs	summer
	Pirimicarb	0	0	unknown	fs	summer
	Malathion	0	0	100mL/100L water	fs	summer
	Acetamiprid	U	U	80-240g/ha	fs	petal fall, summer
	(Z)-11-tetredeceb-1-yl-acetate	U	U	250-500mL/ha	fs	spring, summer

Table 41: Tree Fruit - Herbicides

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method*	Timing/Notes
Cherries (938)	Glyphosate	H	1-2	2.25-12 L/ha		mid-spring
Southern Interior:	Paraquat	H	1-3	5.5L/ha in 440L water		throughout season, before vegetation is 10 cm high
Okanagan, Similkameen, Creston Valley	Pendimethalin	ML	1	4.2L/ha		late winter or early spring
	Metochlor	L	1	1.25-1.75L/ha		late winter or early spring
	Bentazon	N	1	1.75L/ha		
	Dichlobenil	N	1	112-168kg/ha		November/December
	Metribuzin	0	0	0.5-1.0kg/ha		throughout season
	Sethoxydim	0	0	0.4-1.1L/ha		throughout season
	2,4-D	0	0	3.75-5.50L/ha in 100L water		spring or post-harvest
	Fluazifop-p-butyl	0	0	2.0L/ha		throughout season
Pears (339)	Glyphosate	VH	2-3	2.25-12 L/ha		spring/summer or fall
Southern Interior (99%):	Simazine	L	1	2.5-5.0kg/ha		spring
Okanagan and Kootenays	Bentazon	0	0	1.75L/ha		
and Vancouver Island (1%)	Napropamide	0	0	7.0-9.0kg/ha		late winter/early spring
	Glufosinate	0	0	27-50mL/10L or 2.7-5.0L/ha		throughout season
	Paraquat	0	0	5.5L/ha		early season, before vegetation is 10 cm high
	Fluazifop-p-butyl	0	0	2.0L/ha		
	Dichlobenil	0	0	220-350kg/ha		November/December
	Metolachlor	0	0	1.25-1.75L/ha		spring
	2,4-D	0	0	1.7L/ha		spring or post-harvest
	Propyzamide	0	0	4.5kg/ha		late October to mid-November
	Sethoxydim	0	0	1.1L/ha		

Table 41: Tree Fruit – Herbicides continued…

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method*	Timing/Notes
Peaches (568)	Paraquat	L	1	5.5L/ha		throughout season
Southern Interior (99%)	Napropamide	0	0	7.0-9.0kg/ha		late winter or early spring
Okanagan and Kootenays	Dichlobenil	N	1	220-350kg/ha		November/December
and Vancouver Island (1%)	Fluazifop-p-butyl	0	0	2.0L/ha		throughout season
	Pendimethalin	M	1	4.2L/ha		late winter or early spring
	Sethoxydim	0	0	1.1L/ha		throughout season
	Metolachlor	0	0	1.25-1.75L/ha		late winter or early spring
	Terbacil	ML	1	150-300L/ha		late winter or early spring
	Glyphosate	VH	2-4	2.25-12 L/ha		mid-spring
	2,4-D	L	1	1.7L/ha		spring or post-harvest
	Metribuzin	0	0	0.5-1.0kg/ha		
Apples (7,538)	Glyphosate	VH	1-2	2.25-12 L/ha		spring/summer or fall
Southern Interior (99%)	Pendimethalin	M	1-2	4.2L/ha		spring
Okanagan and Kootenays	Simazine	ML	1	1.1-5.0kg/ha		spring
and Vancouver Island and Lower Mainland (1%)	Paraquat	L	1	5.5L/ha		early season
	Clopyralid	L	1	0.56L/ha		early flowering
	Dichlobenil	N	1	220-350kg/ha		November/December
	2,4-D	N	1	1.7L/ha		spring or post-harvest
	Amitrole	N	1	2.25-3.25kg/ha		throughout season
	Napropamide	0	0	7.0-9.0kg/ha		late winter/early spring
	Fluazifop-p-butyl	0	0	2.0L/ha		
	Sethoxydim	0	0	1.1L/ha		
	Metolachlor	0	0	1.25-1.75L/ha		spring
	Propyzamide	0	0	4.5kg/ha		late October to mid-November
	Terbacil	0	0	150-300L/ha		early spring
	Metribuzin	0	0	0.5-1.0kg/ha		
	Glufosinate	0	0	27-50mL/10L or 2.7-5.0L/ha		throughout season

*application methods unknown but assumed to be mainly foliar spray

Table 42: Berries – Fungicides

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method	Timing/Notes
Blueberries (2,579)	Captan*	H	2	2.25kg/1000L	fs	apply at start of blossom through ripening
(Lower Mainland and Vancouver Island)	Copper	H	2	2.0-4.0kg/ha in 500-1000L water	fs	do not apply to new spring foliage
	Triforine	H	2	3L/ha in 1000L water	fs	apply on developing leaf buds and repeat in 10-14 days
	Azoxystrobin	M	2	not registered for use according to PMRA label	fs	incorporate into fungicidal rotations
	Chlorothalonil*	ML	1	7.2L/ha	fs	apply at green tip, pink bud and petal fall
	Ferbam	ML	1	3.75kg/ha in 1000L water	fs	apply at start of blossom and through ripening
	Metalaxyl-M	ML	1	3.6lb./ac.	sd	apply in early spring prior to growth
	Propiconazole**	ML	2	500mL in min of 200L of water	fs	apply on developing leaf buds and repeat in 10-14 days
	Copper	L	1	2.0-4.0kg/ha in 500-1000L water	fs	do not apply to new spring foliage
	Agrobacterium radiobacter	0	0	unknown	i	pre-plant
Cranberries (1,476)	Chlorothalonil*	M	1-2	6.8-11.6L/ha	fs	up to 3 applications per year
(Lower Mainland and Vancouver Island)	Copper	ML	1	ML	fs	up to 3 applications per year
	Propiconazole	L	1	0.5L/ha	fs	up to 4 applications per year
	Triforine	L	1	3.0L/ha	fs	up to 4 applications per year
	Ferbam	0	0	6.75kg/ha	fs	up to 3 applications per year
	Folpet	0	0	10kg/ha	fs	do not exceed 8kg per season; product no longer used
Currants and gooseberries (710)	Copper	U	U	3-5kg/1000L + 4kg/1000L	fs	spray at 7 day intervals in spring
	Ferbam	U	U	6.75kg/ha	fs	spray at 7 day intervals in spring

Table 42: Berries – Fungicides continued…

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method	Timing/Notes
Raspberries (2,031)	Captan*	VH	1	2.5kg/ha	fs	blossom to harvest
(Lower Mainland and Vancouver Island)	Metalaxyl-M	M	1	37mL/100m	sd	post-harvest
	Ferbam	ML	1	6.5kg/ha	fs	apply at delayed dormancy or post-harvest
	Fosetyl-aluminum	ML	1	5.5kg/ha in 200-1000L water	fs	pre-bloom to post-harvest
	Sulphur, lime sulphur	ML	1	0.7 to 7L with 20-200L water	fs	apply at budburst
	Iprodione	L	1	2 kg/ha in 1000L	fs	blossom to harvest
	Copper	N	1	2.5kg/ha mixed in 1000L water	fs	begin at budburst, apply at dormancy
	Thiophanate-methyl	N	1	1.1kg/ha	fs	blossom to harvest
	Agrobacterium radiobacter	N	U	unknown	I	apply pre-plant to cuttings or roots
Strawberries (643)	Captan*	VH	3	2.75-4.25kg/1000L per ha	fs	applied when first blossoms open (May/June)
(Lower Mainland and Vancouver Island)	Fenhexamid	H	1	1.12-1.7kg/ha	fs	applied when first blossoms open (May/June)
	Metalaxyl-M	H	1	20-100mL/100m	d	applied late October/November
	Fosetyl-aluminum	M	1	5.6kg/ha	fs	applied inspring+/or fall before leaves die
	Iprodione	ML	1	2 kg/ha in 1000L	fs	applied when first blossoms open (May/June)
	Sulphur, lime sulphur	N	1	1.0-10.0L with 20-200L water	fs	applied well before fruit ripening or after harvest
	Thiophanate-methyl	N	1	1.1kg/ha	fs	7 – 14 days (April/May) before blossoms open
	Thiram	N	1	2.25-2.5kg/L	fs	applied when first blossoms open (May/June)
	Chlorothalonil*	N	1	3.5L/ha	fs	applied when first blossoms open (May/June)
	Copper	N	1	2.5-3.8kg/ha in 1000L water	fs	7 – 14 days (April/May) before blossoms open
	Folpet	N	1	2.0-4.0kg/ha	fs	applied when first blossoms open (May/June)
	Vinclozolin	N	<5	2.0kg/ha	fs	applied when first blossoms open (May/June)
Grapes (2,467)	Sulphur	VH	U but low	1.5-13.0kg/ha	fs	after flowering (July), most common in Southern Interior
(Southern Interior)	Iprodine	H	0-5	1.5kg/ha in 900L	fs	
	Cyprodinil	M	0-5	750g/ha	fs	these three are rotated
	Fenhexamid	M	0-5	1.12kg/ha	fs	these three are rotated, is a strobilurin fungicide
	Myclobutanil	M	U	3.0-5.0oz/ac	fs	these three are rotated
	Copper	N	U	2oz/2gallons waters	fs	
	Captan*	N	max3	2-3.5kg/ha	fs	
	Azoxyostrobin	U	U	0.8-1.0L/ha	fs	new on the market use figures unknown

* note product label indicates that it is toxic to fish not to apply directly or indirectly to water

**This product contains a petroleum distillate which is moderately to highly toxic to aquatic organisms.

Table 43: Berries – Insecticides

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method	Timing/Notes
Blueberries (2,579)	Imidacloprid	ML	1-2	unknown	fs	apply post-bloom
(Lower Mainland and Vancouver Island)	Deltamethrin	ML	1	250-300mL/ha	fs	do not apply during blossom or fruiting
	Azinophos-methyl	L	1	2.25-4.75L/ha	fs	do not apply during blossom
	Bacillus thuringiensis sp. Kurstaki	L	1	0.25-21lbs./100gal	fs	apply when caterpillars are young
	Carbaryl	N	1	2.5-5.5 L/ha	fs	do not apply during blossom
	Malathion	N	1	7.5-12.5kg/ha, 1-2.5L per 1000L water	fs	do not apply during blossom
	Phosmet	N	1	2.25kg/ha in 1000L water	fs	do not apply during blossom, July 15-30
Cranberries (1,476)	Diazinon	VH	2-3	3.75-7.3kg/ha	fs	apply when action threshold exceeded, larvae sm.-med.
(Lower Mainland and Vancouver Island)	Acephate	ML	1	0.75kg/ha	fs	apply to first generation larvae, prior to bloom
	Phosmet	N	1	2.2kg/ha	fs	apply when action threshold exceeded, larvae sm.-med.
	Tebufenzide	N	2	3L in 475L water	fs	apply at hatch of larvae and 10 days later
	Malathion	0	0	7.5-12.5kg/ha, 1-2.5L per 1000L water	fs	hardens fruit early, not used
	Azinophos-methyl	0	0	1.1-2.25kg/ha powder, 2.25-4.75L/ha liquid	fs	apply at larval stage when threshold exceeded
	Carbaryl	0	0	6.25-7kg/ha, 6.4-7.6L/ha	fs	apply when action threshold exceeded, larvae sm.-med.
Currants and gooseberries (710)	Azinophos-methyl	U	U	unknown	fs	prior to 14 days of harvest, when adult pests are observed
	Diazinon	U	U	1L/ha, 1kg/1000L	fs	apply when aphids become numerous, prior to flowers opening

Table 43: Berries – Insecticides continued…

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method	Timing/Notes
Hazelnuts (unknown)	Malathion	U	U	2-2.25 kg/1000L	fs	apply when aphids are numerous, spray on green fruit
	Chlorpyrifos	U	U	4.2-4.8L/ha	g	max. 3 ground applications per year
	Dimethoate	U	U	5L/ha	unknown	apply on young trees when aphids appear
Raspberries (2,031) (Lower Mainland and Vancouver Island)	Diazinon	H	2	2.24-4.48kg/ha in 100gal water	fs	do not apply during blossom
	Azinophos-methyl	H	2	2.5L/ha	fs	apply before harvest
	Bacillus thuringiensis sp. Kurstaki	M	1	0.25-21lbs./100gal	fs	apply based on caterpillar monitoring.
	Azinophos-methyl	ML	1	4.75-9.25L/ha	apply to base	apply before harvest
	Diazinon	ML	1-2	2.24-4.48kg/ha in 100gal water	d	apply in fall or spring when growth is 10cm
	Oxamyl	ML	1	9.35L/ha.	d	apply after harvest; in fall before Oct 31; toxic to fish & wildlife
	Azinophos-methyl	N	1-2	3.5L/ha	d	apply before fruit set or after harvest
	Carbofuran	N	1	1.1-2.5L/ha	canes & soil	apply before May 7th
	Clofentezine	N	1	500mL/ha	fs	apply when spider mites appear
	Dicofol	N	1	unknown	fs	apply when spider mites appear
	Malathion	N	1-2	7.5-12.5kg/ha, 1-2.5L per 1000L water	fs	apply just before bloom
	Pyridaben	N	1	1.2kg/ha	fs	apply after harvest
	Trichogramma minutum	N	2	unknown	bg	apply based on caterpillar monitoring
	Abamectin	N	1	1.0L/ha	fs	apply after harvest
Strawberries (643) (Lower Mainland and Vancouver Island)	Dimethoate	M	1	2.25-2.75L/ha	fs	apply when aphids are first detected
	Endosulfan	M	1	2.0-4.0kg/ha	fs	varies depending on the targeted pest; very toxic to fish
	Cyhalothrin-lambda	M	1	104mL/ha	fs	varies depending on the targeted pest; apply prior to harvest
	Cypermethrin	ML	1	0.1-0.14L/acre	fs	varies depending on the targeted pest; apply prior to harvest
	Diazinon	ML	1	0.84-2.24kg/ha in 100gal of water	fs	apply when aphids are first detected, or just before bloom
	Pirimicarb	ML	1	275g/ha	fs	apply 3 weeks after planting, or when aphid are first detected
	Clofentezine	ML	1	500mL/ha	fs	apply at the first sign of mite activity
	Vapam	L	1	470-900L/ha	sf	pre-plant; fall or spring; toxic to fish
	Metaldehyde	L	1	11.2-44.8kg/ha	d	apply early spring surface broadcast/during fruiting & flowering
	Methyl bromide	N	1	3.2-5.0kg/100m3	sf	pre-plant; toxic to fish and wildlife
	Naled	N	1	1.1L/ha	fs	apply when pests are detected
	Parathion	N	1	1.75-2.0kg/ha in 1000L water	fs	apply during October or in early spring
	Malathion	N	1	7.5-12.5kg/ha, 1-2.5L per 1000L water	fs	apply when pests are first detected
	Carbaryl	N	1	2.5-5.5 L/ha	fs	apply when pests are present at the first sign of bloom
	Carbofuran	N	1	1.1-2.5L/ha in 1000L water	fs	apply post harvest
	Dicofol	N	1	2.25-5.50kg/ha	fs	apply when number of mites begin to build
Grapes (2,467) (Southern Interior)	Carbaryl	M-ML	1-2	5.25-6.4L/ha		unknown
	Permethrin	ML	1	146-286mL/ha		unknown
	Acetamiprid	L	1	80g/ha		new product for leaf hoppers
	Sulphur	L	1	1.5kg/ha in 45L water		after flowering prior to pod set
	Insecticidal soap	N	1-2	20mL/L of water		unknown
	Pyridaben	0	0	unknown		Unknown
	Azinphos-methyl	0	0	4.275-5.7L/ha		Unknown
	Phosalone	0	0	2.0L/ha		not effective in BC
	Malathion	0	0	unknown		Unknown
	Mineral Oil	0	0	unknown		Unknown
	Diazinon	0	0	1.12-2.24kg/ha or 420mL/ha in 100gal of water		Unknown
	Dicofol	0	0	1.25-3.0kg/ha		toxic to fish
	Endosulfan	0	0	1.0kg/ha in 1000L water, 2500L/ha		very toxic to fish
	Azinphos-methyl	0	0	1.25-4.0L/1000L		unknown

Table 44: Berries – Herbicides

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method	Timing/Notes
Blueberries (2,579)	Glyphosate	H	1	1.26-3.5L/ha, 2.28-5.6L/ha	U	post-emergent
(Lower Mainland and Vancouver Island)	Dichlobenil	L	1	112-168kg/ha	U	pre-emergent
	Fluazifop-p-butyl	L	1	2.0L/ha	U	post-emergent
	Hexazinone	L	1	1.49-2.99kg/ha	U	post-emergent; spring before fruiting bud breaks
	Napropamide	L	1	9.0kg/ha	U	pre-emergent
	Paraquat	L	1-2	5.5L/ha in 440L water	U	post-emergent
	Sethoxydim	L	1	0.4-1.1L/ha	U	post-emergent
	Simazine	L	1	2.5-3.75kg/ha in 300L	U	pre-emergent
	Terbacil	N	1	1.12-2.24kg/ha	U	pre-emergent; late winter early spring
	Bentazon	N	1	1.75L/ha in 100-400L/ha water	U	post-emergent
	Clopyralid	N	1	0.42-0.83L/ha	U	post-emergent
Cranberries (1,476)	2,4-D	VH	1	dilute 1:2 in water/ha	U	post-emergent
(Lower Mainland and Vancouver Island)	Dichlobenil	VH	2	110kg/ha	G	post emergent, early spring
	Glyphosate	VH	1	1.26-3.5L/ha, 1.0L/4Lwater	U	post-emergent
	Mineral Oil	VH	1	3500-1600L/ha	fs or g	apply before bud break
	Napropamide	VH	1	9.0kg/ha	bg	pre-emergent, late winter
	Clopyralid	ML	1	2% solution/ha (20mL/Lha)	U	post-emergent
	Sethoxydim	U	U	0.4-1.1L/ha	fs or g	post-emergent
	Fluazifop-p-butyl	U	U	2L/ha	fs or g	post-emergent
Currants and gooseberries (710)	Paraquat	U	U	5.5L/ha in 1100L water	U	apply first spray in early spring, repeat as needed
Hazelnuts (unk)	Glyphosate	U	U	1.26-3.5L/ha, 2.25-3.5L/ha	U	use for plantings established more than one year
	Paraquat	U	U	75ml/10L of water	U	use for plantings established more than one year
	Simazine	U	U	2.0-2.5kg/ha	U	early spring before seedling weeds emerge
Raspberries (2,031)	Oxyflurofen	VH	1	0.2-0.75lb/acre in 50gal of water	U	established plantings
(Lower Mainland and Vancouver Island)	Simazine	H	1	2.0-2.5kg/ha in 300L	U	establishing plantings
	Paraquat	ML	1	5.5L/ha in 440L water	U	established plantings, before petal drop or post-harvest
	Terbacil	L	1	1.12-2.24kg/ha	U	established plantings
	Napropamide	L	1	9.0kg/ha	U	year of planting, established plantings, pre-bloom
	Dichlobenil	L	1	112kg/ha	U	establishing plants, post-harvest
	Fluazifop-p-butyl	N	1	1.2-2.0L/ha	U	year of planting, established plantings
	Glufosinate ammonium	N	1	6.67L/ha	U	establishing plants
	Sethoxydim	N	1	0.4-1.1L/ha	U	year of planting, established plantings
Strawberries (643)	Napropamide	H	1	9.0kg/ha	U	year of planting or mature plantings, prior to bloom or post-harvest
(Lower Mainland and Vancouver Island)	Simazine	H	1	2.0kg/ha in 300L	U	year of planting or mature plantings, prior to bloom or post-harvest
	Propyzamide	ML	1	unknown	U	mature plantings, post-harvest
	Clopyralid	L	1	0.56-0.83L/ha	U	mature plantings, post-harvest
	Fluazifop-p-butyl	L	1	2.0L/ha	U	year of planting or mature plantings, prior to bloom or post-harvest
	Sethoxydim	L	1	0.4-1.1L/ha	U	year of planting or mature plantings, prior to bloom or post-harvest
	Terbacil	L	1	1.12-2.24kg/ha	U	year of planting or mature plantings, prior to bloom or post-harvest
	Trifluralin	L	1	1.0-1.8kg/ha, 1.3-1.8L/ha	U	pre-plant
	S-metolachlor	N	1	1.25-1.75L/ha	U	pre-plant or year of planting
Grapes (2,467)	Glyphosate	VH	1-3	2.25-12L/ha with 2.0-4.5kg ai/h Simazine	Fs	
(Southern Interior)	Paraquat	L	1	5.5L/ha in 440L of water	Fs	
	Dichlobenil	N	1	112-168kg/ha	Fs	in winter
	Napropamide	N	1	9.0kg/ha	Fs	winter or spring
	Glufosinate	N	1	2.7-5.0L/ha	Fs	
	Diuron	N	1			

Table 45: Vegetable Crops – Fungicides

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method*	Timing/Notes
Beans (799)	Captan	H	1		st	
(Snap or Green)	Thiram	H	1	25-35g/25kg of seed	st	
	Vinclozolin	M	1	1.0-1.5kg/ha	fs	all processing beans are treated with this product
	Iprodione	L	1	1.5kg/ha in 300/500L	fs	
	Benomyl	N	1	1.75-2.25kg/ha	fs	going off the market this year
Carrots (381)	Chlorothalonil	ML	1	2.4-3.2L/ha (3-5days)	fs	
	Mancozeb	N	1	2.25kg/ha	fs	
	Zineb	N	1	1.1-3.3kg/ha	fs	
	Metaxyl M	U	U	25kg/ha	fs	
	Metiram	U	U	2.25kg/ha	fs	
	Pyraclostrobin	U	1-3	1.1kg/ha	fs	just registered no figures
Broccoli (612)	Chlorothalonil	M	U	2.5-4.8L/ha	fs	2 fungicides applied
	Copper	L	U	4kg/ha	fs	
	Fosetyl al	L	U	2.25-3.125kg/ha	fs	
	Zineb	N	U	1.1-3.3kg/ha	fs	
Cauliflower (214)	Chlorothalonil	M	U	2.5-4.8L/ha	fs	
	Copper	N	1	4kg/ha	fs	
	metam sodium	N	U	?	fs	
	methyl bromide	N	U	?	fs	
	dazomet	N	U	3.25-5.0kg per 100m2	fs	
	Fosetyl al	N	U	2.25-3.125kg/ha	fs	
	Iprodione	N	U	3.0 kg/ha	gs	1-2 days prior to tying
	Zineb	N	U	1.1-3.3kg/ha	fs	
Brussels Sprouts (294)	Chlorothalonil	ML	U	2.5-4.8L/ha	fs	
	Copper	M	U	4kg/ha	fs	
	metam sodium	N	U	?	fs	
	methyl bromide	N	U	?	fs	
	dazomet	N	U	3.25-5.0kg per 100m2	fs	
	Fosetyl al	N	U	2.25-3.125kg/ha	fs	
	Zineb	N	U	1.1-3.3kg/ha	fs	
Cabbage (290)	Chlorothalonil	M	U	2.5-4.8L/ha	fs	
	Copper	N	U	4kg/ha	fs	
	metam sodium	N	U	?	fs	
	methyl bromide	N	U	?	fs	
	dazomet	N	U	3.25-5.0kg per 100m2	fs	
	Fosetyl al	N	U	2.25-3.125kg/ha	fs	
	Iprodione	N	1	3kg/ha	gs	7-14 days before harvest
	Zineb	N	U	1.1-3.3kg/ha	fs	
Lettuce (341)	Thiram	VH	1	90g per 25kg of seed	st	
	Metaxyl M	H	2	2.5kg/ha	fs	
	Fosetyl al	ML	1	2.8kg/ha	fs	
	Iprodione	ML	1	1.5kg/ha	gs	
	Vinclozolin	L	1	1.1kg/ha	fs	
	Zineb	L	1	1.7-2.3kg/ha	fs	
Green Peas (854)	Metaxyl M	VH	1	25kg/ha	st	

Table 45: Vegetable Crops – Fungicides continued…

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method*	Timing/Notes
Potatoes (3,507)	Metaxyl M/chlorothalonil/mancozeb	VH	1-2	2.5kg/ha	fs	
	Chlorothalonil	VH	1-5	1.2-2.4L/ha	fs	
	Cymoxalin	H	1-2	225g/ha	fs	
	Mancozeb	H	1-5	1.1-2.25kg/ha	fs	most common non-systemic fungicide
	Mancozeb + Dimethomorph	ML	1-3	2.5kg/ha	fs	
	Mancozeb/ Zoxamide	ML	1-4	2.25kg/ha	fs	
	Chlorothalonil	M	1-3	2.7L/ha	fs	
	+ Propamocarb Hydrochloride				fs	
	Copper	M	1-2	4-7.0kg/ha	fs	toxic to fish
	Copper hydroxide	M	U	1.1-2.25kg/ha	fs	used for organic growers
	Captan	0	0	2.5-3.75 kg/ha	fs	
	Metiram	0	0	1.1-2.25kg/ha	fs	
	Zineb	0	0	2.0-3.0kg/ha	fs	
	Zoxamide	U	U	175-235g/ha	fs	
	Chlorpropham	U	U	1gallon:35gallons of water	fs	
	Maleic Hyrazide	U	U	5.65kg/ha	si	

*application methods unknown but assumed to be mainly foliar spray

Table 46: Vegetables – Insecticides

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method*	Timing/Notes
Beans (799) (Snap or Green)	Diazinon	N	1	1.0-1.1kg/ha	fs	
	Dimethoate	N	1	700-1000mL/ha		
	Endosulfan	N	1	1.5-2.5L/ha		
	Malathion	N	1	1.5-2.75L/ha		
Carrots (381)	Cypermethrin	M	0-2	280mL/ha		
	Diazinon	L	0-2	1.1L/ha		
	metam sodium	N	U	unknown		
Broccoli (612)	Chlorpyrifos	VH	U	1.2-2.4L/ha		
	Deltamethrin	H	U	150-200mL/ha		
	Cyhalothrin-lambda	ML	U	42-200mL/ha		
	Dimethoate	ML	U	1.0L/ha		
	Methomyl	ML	U	270-540g/ha		
	Permethrin	ML	U	90-180mL/ha		
	Cypermethrin	M	U	88-140mL/ha		
	Endosulfan	L	U	1.5-2.0L/ha		
	Methamidophos	L	U	1.1-2.25L/ha		
	Azinphos-methyl	N	U	1.1-1.75kg/ha		
	Azinphos-methyl	N	max of 3	1.1-1.75kg/ha		
	Baccillus Thuringiensis Berliner ssp kurstaki	N	U	1.4 - 2.8L/ha		
	Diazinon	N	U	1.1L/ha		
	Naled	N	U	1.1-2.2L/ha		
	Acephate	0	0	750-1100g/ha		
	Azinphos-methyl	U	U	1.1-1.75kg/ha		

Table 46: Vegetables – Insecticides continued…

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method*	Timing/Notes
Cauliflower (214)	Chlorpyrifos	VH	U	1.2-2.4L/ha		
	Deltamethrin	H	U	150-200mL/ha		
	Cyhalothrin-lambda	ML	U	42-200mL/ha		
	Dimethoate	ML	U	1.0L/ha		
	Methomyl	ML	U	270-540g/ha		
	Permethrin	ML	U	90-180mL/ha		
	Cypermethrin	M	U	88-140mL/ha		
	Endosulfan	L	U	1.1-1.75kg/ha		
	Methamidophos	L	U	1.1-2.25L/ha		
	Acephate	N	U	750-1100g/ha		
	Azinphos-methyl	N	U	2.25-3.5L/ha		
	Baccillus Thuringiensis Berliner ssp kurstaki	N	U	1.4 – 2.8L/ha		
	Diazinon	N	U	1.1L/ha		
	Naled	N	U	1.1-2.2L/ha		
	Endosulfan	U	U	1.5-2.0L/ha		
Brussels Sprouts (294)	Acetmapiprid	VH	2-3	56-86g/ha		
	Chlorpyrifos	VH	U	1.2-2.4L/ha		
	Cyhalothrin-lambda	H	U	42-200mL/ha		
	Deltamethrin	H	U	150-200mL/ha		
	Dimethoate	H	2	1.0L/ha		
	Methomyl	H	1-2	270-540g/ha		
	Acephate	M	U	750-1100g/ha		
	Cypermethrin	M	U	88-140mL/ha		
	Permethrin	M	U	90-180mL/ha		
	Endosulfan	L	U	1.1-1.75kg/ha		
	Methamidophos	L	U	1.1-2.25L/ha		
	Diazinon	N	U	1.1L/ha		
	Azinphos-methyl	N	U	2.25-3.5L/ha		
	Baccillus Thuringiensis Berliner ssp kurstaki	N	U	1.4 - 2.8L/ha		
	Naled	N	U	1.1-2.2L/ha		
	Diazinon	U	U	1.1L/ha		
	Dimethoate	U	U	1.0L/ha		
	Endosulfan	U	U	1.5-2.0L/ha		
Cabbage (290)	Chlorpyrifos	VH	U	1.2-2.4L/ha		
	Cypermethrin	VH	U	140mL/ha		
	Chlorpyrifos	VH	1-2	1.2-2.4L/ha		
	Deltamethrin	H	U	150-200mL/ha		
	Dimethoate	H	U	1.0L/ha		
	Methomyl	M	U	270-540g/ha		
	Diazinon	M	U	1.1L/ha		
	Cypermethrin	M	1-2	88-125mL/ha		
	Dimethoate	ML-M	1-2	1.0L/ha		
	Methamidophos	ML	U	1.1-2.25L/ha		
	Acetmapiprid	ML	U	56-86g/ha		
	Dimethoate	M	U	1.0L/ha		
	Diazinon	L-ML	1	1.1L/ha		
	Azinphos-methyl	L	1	2.25-3.5L/ha		
	Acephate	L	U	750-1100g/ha		
	Naled	L	U	1.1-2.2L/ha		
	Permethrin	L	U	90-180mL/ha		
	Cyhalothrin-lambda	L	U	42-200mL/ha		
	Endosulfan	L	U	1.1-1.75kg/ha		
	Azinphos-methyl	N	U	1.1-1.75kg/ha		
	Baccillus Thuringiensis Berliner ssp kurstaki	N	U	1.4 – 2.8L/ha		

Table 46: Vegetables – Insecticides continued…

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method*	Timing/Notes
Cabbage continued…	Endosulfan	U	U	1.5-2.0L/ha		
	Methomyl	U	U	270-540g/ha		
Sweet Corn (1,354)	Carbaryl	U	U	2.5-4.0L/ha		
	Cypermethrin	no available data	U	175mL/ha		
	Deltamethrin	U	U	250-300mL/ha		
	Metaldehyde	U	U	25kg/ha		
	Methomyl	U	U	430-625g/ha		
	Permethrin	U	U	275-375mL/ha		
	Pirimicarb	U	U	550g/ha		
	Tefluthrin	U	U	3.75kg/ha		
	Terbufos	U	U	7.5kg/ha		
Lettuce (341)	Dimethoate	VH	2-3	700mL/ha		
	Methomyl	VH	U	0.51-1.0kg/ha		
	Methamidophos	H	1-2	2.25L/ha		very toxic
	Pirimicarb	H	1-3	500g/ha		
	Acephate	ML	1	750-1100g/ha		
	Endosulfan	ML	1	1.75kg/ha		
	Malathion	L	1	1.5-2.75L/ha		
	Metaldehyde	L	U	25kg/ha		
	Naled	L	1	1.65L/ha		
	Baccillus Thuringiensis Berliner ssp kurstaki	L	U	1.4-2.8L/ha		
	Imidacloprid	N	1	200mL/ha		
	Cypermethrin	0	0	125-200mL/ha		
	Acetamiprid	U	U	56-86g/ha		
	Cyhalothrin-lambda	U	U	83mL/ha		
	Endosulfan	U	U	2.0L/ha		
	Ferric phosphate	U	U	24-50kg/ha		
Green Peas (854)	Dimethoate	H	1	425mL/ha		
	Malathion	N	1	1.0-2.25L/ha		
	Methomyl	N	U	510g/ha		
	Methoxychlor	N	U	1.7-5.0kg/ha		
	Pirimicarb	N	U	150-275g/ha		
	Dimethoate	U	U	425mL/ha		
Potatoes (3,507)	Pirimicarb	VH	1-3	425-550g/ha		
	Cypermethrin	H	1-4	180-260mL/ha		
	Carbaryl	ML	1-3	1.25L/ha		
	Chlorpyrifos	ML	1	1.0L/ha		
	Deltamethrin	ML	1-2	100-250mL/ha		
	Endosulfan	ML	1-3	1.5-2.0L/ha		
	Phosmet	ML	1	2.25kg/ha		
	Dimethoate	M	1-2	0.55-1.1L/ha		
	Methamidophos	M	1-2	1.75-2.3L/ha		
	Cyhalothrin-lambda	L	2	83-200mL/ha		
	Carbofuran	N	1	0.55-1.1L/ha		
	Imidacloprid	N	1	344-525mL/ha sd; 240mL/ha fs	fs or sd	
	Malathion	0	0	1.5-2.0L/ha		
	Methoxychlor	0	0	6.0L/ha		
	Naled	0	0	1.1L/ha		
	Permethrin	0	0	62.5-140mL/ha		
	Acephate	0	0	1.1-1.75kg/ha		
	Azinphos-methyl	0	0	1.1-1.75kg/ha		

*application methods unknown but assumed to be mainly foliar spray

Table 47: Vegetable Crops – Herbicides

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method*	Timing/Notes
Beans (799) (Snap or Green)	Trifluralin	H	1	1.1-2.75L/ha		
	Bentazon	M	1	1.75-2.25L/ha		
	EPTC	L	1	4.25-5.5L/ha		
	Metobromuron	L	1	2.5-3.5L/ha		
	Monolinuron	L	1	5.5L/ha or 7.0L/ha		
	Sethoxydim	L	1	320-470ml/ha or 1.1L/ha		
	S-metolachlor	U	unknwon	1.15-1.75L/ha		
Carrots (381)	Linuron	VH	1	1.1-3.4L/ha		
	Sethoxydim	ML	1	320mL/ha to 1.1L/ha		
	Trifluralin	L	1	1.1-2.75L/ha		
	Fluazifop-P-butyl	L	1	0.8-2.0L/ha		
	Diclofop methyl	N	1	3.5L/ha		
	Fenoxaprop-p-ethyl	N	1	670mL/ha		
	Prometryne	N	1	3.75lL/ha or 4.58L/ha or 7.08L/ha		
	Stoddard solvent	N	1	600-800L/ha		
Broccoli (612)	Trifluralin	H	1	1.1-2.75L/ha		
	Fenoxaprop-p-ethyl	L	1	670mL/ha		
	Fluazifop-P-butyl	L	1	0.8-2.0L/ha		
	Napropamide	L	1	2.25-4.5kg/ha		
	Pyridate	L	1	2.0kg/ha		
	Sethoxydim	L	1	320-470mL/ha		
	S-metolachlor	L	1	1.25-1.75L/ha		
Cauliflower (214)	Trifluralin	VH	1	1.1-2.75L/ha		
	Fenoxaprop-p-ethyl	N	1	670mL/ha		
	Fluazifop-P-butyl	N	1	0.8-2.0L/ha		
	Napropamide	N	1	2.25-4.5kg/ha		
	Pyridate	N	1	2.0kg/ha		
	Sethoxydim	N	1	320mL/ha to 1.1L/ha		
	S-metolachlor	N	1	1.25-1.75L/ha		
Brussels Sprouts (294)	Trifluralin	H	1	1.1-2.75L/ha		
	Fenoxaprop-p-ethyl	N	1	670mL/ha		
	Fluazifop-P-butyl	N	1	0.8-2.0L/ha		
	Napropamide	N	1	2.25-4.5kg/ha l		
	Pyridate	N	1	2.0kg/ha		
	Sethoxydim	N	1	320-470mL/ha		
	S-metolachlor	N	1	1.25-1.75L/ha		
Cabbage (290)	Trifluralin	H	1	1.1-2.75L/ha		
	Fluazifop-P-butyl	L	1	0.8-2.0L/ha		
	Napropamide	L	1	2.25-4.5kg/ha		
	Fenoxaprop-p-ethyl	N	1	670mL/ha		
	Pyridate	N	1	2.0kg/ha		
	Sethoxydim	N	1	320mL/ha to 1.1L/ha		
	S-metolachlor	N	1	1.25-1.75L/ha		
Sweet Corn (1,354)	Atrazine	U	U	1.1kg/ha or 2.1L/ha		
	Bentazon	U	U	1.75-2.25L/ha		
	Bentazon/ atrazine	U	U	3.0-4.0L/ha		
	Bromoxynil	U	U	585mL/ha or 1.0-1.2L/ha		
	EPTC	U	U	5.5L/ha		
	Paraffin base mineral oil	U	U	2.75-5.5L/ha		
	Pyridate	U	U	1.0kg/ha		
	S-metolachlor	U	U	1.25-4.0L/ha		
	Paraffin base mineral oil	U	U	1.0-2.0L/ha		

Table 47: Vegetable Crops – Herbicides continued…

Crop / Land area (ha)	Active Ingredient	% Acreage Treated	Estimated # of Applications/Year	Label Rate	Application Method*	Timing/Notes
Lettuce (341)	Glufosinate ammonium	U	U	2.7-5.0L/ha		
	Glyphosate	U	U	0.75-3.5L/ha		
	Propyzamide	U	U	2.2kg/ha		
Green Peas (854)	Bentazon	H	1	1.75-2.25L/ha		post emergent
	Trifluralin	H	1	1.1-2.75L/ha		pre plant
	Metribuzin	M	1	275-375g/ha		
	Prometryne	ML	1	3.75-4.58L/ha		pre plant
	Sethoxydim	L	1	320mL/ha -1.1L/ha		
	Paraffin base mineral oil	U		1.0-2.0L/ha		mixed with Basagran
	Quizalofos-P-ethyl	U	unknown	0.38-0.75L/ha		
	MCPB + MCPA	N	1	2.75-4.25L/ha		
Potatoes (3,507)	Linuron	VH	1	2.2-4.3kg/ha		
	Diquat	VH	1-2	1.25-3.5L/ha		
	Monolinuron	M	1	5.5-11.0L/ha		not available after 2003
	Paraquat	M	1	1.5-4.25L/ha		pre-emergent before crop is planted
	Clethodim	L	1	0.125-0.38L/ha		
	Fluazifop-P-butyl	L	1	0.8-2.0L/ha		
	Metribuzin	L	1	0.6-1.4kg/ha		coastal and interior BC
	Rimsulfuron	L	1	60g/ha		
	Sethoxydim	L	1	0.32-1.1L/ha		
	Glyphosate	L	1	2.5-7.0L/ha		
	Glufosinate ammonium	L	1-2	2.7-5.0L/ha		not registered to use on seed
	Nonylphenoxypolyethoxyethanol	U	U	2.0L/1000L of spray solution		surfactant no numbers
	Octyphenoxypolyethoxyethanol	U	U	2.0L/1000L of spray solution		surfactant no numbers
	Surfactant blend	U	U	1.0-2.0L/ha		surfactant no numbers
	Diclofop methyl	0	0	3.5L/ha		
	EPTC	0	0	4.25-8.5L/ha		
	Fenoxaprop-p-ethyl	0	0	670mL/ha		
	S-metolachlor	0	0	1.25-1.75L/ha		
	Metobromuron	0	0	2.5-8.5L/ha		

*application methods unknown but assumed to be mainly foliar spray

Table 48: Forage Crops

Fungicides	Insecticides	Herbicides
Chlorothalonil Elemental sulfur	Chlorpyrifos Deltamethrin Cyhalothrin lambda Carbaryl	2,4-D atrazine Fipronil metsulfuron methyl bentazon fluazifop-p-butyl nicosulfuron bromoxynil fluroxypryr quinclorac clodinafop-propargyl / cloquintocet-mexyl glufosinate ammonium quizalofop-ethyl clopyralid glyphosate sethoxydim

		dicamba imazamethabenz s-metolachlor and R-enantiomer ethalfluralin imazamox + imazethapyr thifensulfuron methyl + tribenuron methyl fenoxaprop-p-ethyl MCPA amine, ester, salts tralkoxydim

APPENDIX E
QUANTITY OF REPORTABLE PESTICIDES SOLD IN BC IN 1999 BY REGION, AS IDENTIFIED BY PMRA

Table 49: Quantity (kg) of reportable pesticides sold in British Columbia (1999) that were identified as being a concern by the Pest Management Regulatory Agency (PMRA) ((ENKON Environmental Limited 2001) - Appendix C).

Active Ingredients	Vancouver Island	Lower Mainland	Southern Interior	Kootenay	Cariboo	Skeena	Peace-Omineca	Total Quantity Sold (kg)
Chlorpyrifos	135	4,189	108	0	0	0	34	**4,466**
Diazinon	358	12,834	11,275	82	6	0	8	**24,563**
Malathion	17	5,924	572	20	118	0	41	**6,691**
Imidacloprid	0	29	159	0	0	0	0	**188**
Endosulfan	26	1,050	3,569	68	0	0	0	**4,712**
Methoprene	0	27	0	0	0	0	0	**27**
Atrazine	230	8,773	987	1	0	0	0	**9,991**
Triallate	0	0	45	0	0	0	3,243	**3,2889**
Trifluralin	9	1,563	82	4	4	0	685	**2,347**
Ethalfluralin	0	8	0	0	0	0	2,281	**2,289**
Pendimethalin	80	615	1,686	23	18	0	0	**2,422**
Glyphosate Acid	526	1,534	853	209	886	0	22,803	**26,810**
Glyphosate, Isopropylamine	1,635	68,859	18,145	342	3,047	206	16,529	**108,763**
Sulfosulfuron	0	0	0	0	0	0	96	**96**
Azoxystrobin	0	0	0	0	0	0	0	**0***
Pyraclostrbin	0	0	0	0	0	0	0	**0***
Kresoxim-methyl	0	0	0	0	0	0	0	**0***
Chlorothalonil	1,037	22,637	2,923	44	0	0	0	**26,640**
Total	**4,050.68**	**128,041.91**	**40,403.17**	**791.84**	**4079.61**	**206.48**	**45720.63**	

*Note: no information available for 3 pesticides, or not reportable.

APPENDIX F
QUANTITY OF REPORTABLE PESTICIDES SOLD IN BC IN 1999 BY REGION

Table 50: Quantity (kg) of reportable pesticides sold in 1999 as identified in Table 8 by region (ENKON Environmental Limited 2001).

Active Ingredient	Tally	Region							Total Sales/Use in 1999 (kg)	Change in amount sold in 1991 (kg)
		Vanc. Is.	Lower Mainland	Southern Interior	Kootenay	Cariboo	Skeena	Peace-Omineca		
Chlorothalonil	4	1,036.51	22,637.03	2,922.75	43.63	0	0	0	26,639.92	22,919.00
Diazinon	4	357.80	12,833.61	11,275.19	81.73	6.41	0	8.25	24,562.99	4,920.00
Endosulfan	4	25.50	1,050.20	3,568.50	67.50	0	0	0	4,711.70	-2,146.00
Trifluralin	4	9.00	1,562.96	81.84	4.00	4.00	0	684.96	2,346.76	-3,510.00
Mancozeb	3	952.31	26,929.63	16,623.67	176.25	0	0	0	44,681.86	15,171.00
Metam	3	1,896.96	21,136.74	7,821.54	0	0	0	0	30,855.24	3,418.00
Glyphosate Acid	3	525.60	1,533.60	853.20	208.80	885.60	0	22,802.77	26,809.57	26,810.00
Malathion	3	16.50	5,924.25	572.00	20.00	118.00	0	40.55	6,691.30	-5,403.00
Chlorpyrifos	3	135.36	4,188.93	107.58	0	0	0	34.32	4,466.19	30.20
Pendimethalin	3	79.80	615.04	1,685.68	22.80	18.24	0	0	2,421.56	2,089.00
Glyphosate, Isopropylamine	2	1,634.50	68,859.02	18,144.80	341.76	3,047.36	206.48	16,529.33	108,763.25	-1,394.00
Captan	2	245.44	20,926.36	5,885.64	440.40	0	0	0	27,497.84	-953.00
Formaldehyde	2	47.36	25,445.04	2.39	0	0	0	0	25,494.79	22,488.00
Bt, Serotype H-14	2	70.00	21,720.40	85.00	0	0	0	0	21,875.40	18,687.00
Bt, Berliner ssp. Kurstaki	2	53.00	6,213.00	11,581.50	47.50	0	0	0	17,895.00	14,800.00
Atrazine	2	229.63	8,772.71	987.11	1.62	0	0	0	9,991.07	-12,907.00
Nonylphenoxypolyethanoxyethanol	2	405.00	5,265.00	2,244.60	36.00	95.68	0	1,199.17	9,245.45	3,660.00
Simazine	2	137.95	5,192.65	2,715.50	33.08	0	0	0	8,079.18	-969.00
Parathion	2	0	3,750.70	40.80	0	0	0	0	3,791.50	-262.80
Triallate	2	0	0	45.40	0	0	0	3,243.42	3,288.82	-17,296.00
Ethalfluralin	2	0	8.75	0	0	0	0	2,280.58	2,289.33	-24,628.00
Permethrin	2	6.00	511.26	60.06	0	0.96	0	0.23	578.51	380.00
Propiconazole	2	18.05	472.25	17.40	0	0	0	0.69	508.39	490.40
Dicofol	2	0	79.10	232.45	1.50	0	0	0	313.05	-422.00
Oxadiazon	2	8.80	272.44	17.60	0	0	0	0	298.84	299.00
Lindane (gamma-BHC)	2	0.40	102.37	72.91	0	6.66	0	56.64	238.98	-87.30

Table 50: continued…

Active Ingredient	Tally	Region							Total Sales/Use in 1999 (kg)	Change in amount sold in 1991 (kg)
		Vanc. Is.	Lower Mainland	Southern Interior	Kootenay	Cariboo	Skeena	Peace-Omineca		
Methoxychlor	2	2.50	35.00	19.20	0	0	0	0	56.70	-114.00
Fenvalerate	2	0	0.23	0	0	0.97	0	0	1.20	-6.20
Azoxystrobin	1	0	0	0	0	0	0	0	NEW	NEW
Kresoxim-methyl	1	0	0	0	0	0	0	0	NEW	NEW
Pyraclostrobin (NEW)	1	0	0	0	0	0	0	0	NEW	NEW
Sulfosulfuron	1	0	0	0	0	0	0	0	NEW	96.40
Sulphur	1	448.08	3,010.53	32,929.81	4.72	0.08	0	0	36,393.22	8,292.00
Metiram	1	16.00	572.80	22,764.80	536.00	0	0	0	23,889.60	-3,728.00
2,4-D Amine	1	428.87	5,824.11	3,933.43	171.36	379.50	0	3,165.39	13,902.66	1,575.00
Dazomet	1	509.60	8,153.60	1,372.00	0	0	0	0	10,035.20	6,586.00
Carbaryl	1	17.50	1,712.26	7,396.61	141.16	3.90	0	0	9,271.43	1,997.00
Surfactant blend	1	27.20	1,089.88	380.90	0	0	0	7,398.33	8,896.31	7,557.00
Quintozene	1	161.92	5,447.67	1,642.98	0	0	0	0	7,252.57	1,440.00
Cupric hydroxide	1	2.50	6,904.85	12.50	0	0	0	0	6,919.85	6,286.00
Napropamide	1	61.55	6,339.97	291.30	0	0	0	0	6,692.82	3,027.00
Metolachlor	1	249.60	4,419.00	949.50	3.30	0	0	0	5,621.40	-5,105.00
Iprodione	1	228.00	3,993.20	1,223.24	33.00	0	0	0	5,477.44	4,274.00
Paraquat	1	106.40	3,385.04	1,217.60	50.00	0	0	58.08	4,817.12	4,817.00
Octylphenoxypolyethanoxyethanol	1	84.51	3,865.91	659.32	17.50	0	0	52.36	4,679.60	2,116.00
Dimethoate	1	48.00	2,358.72	1,832.16	36.00	0	0	0	4,274.88	1,276.00
Linuron	1	135.60	3,323.60	69.45	0	4.80	0	0	3,533.45	1,543.00
Mecoprop amine	1	188.55	2,096.80	1,063.75	32.40	20.00	0	131.88	3,533.38	651.00
Metalaxyl	1	54.98	3,125.56	281.19	0	0	0	1.20	3,462.93	2,481.00
Maelic hydrazide	1	6.78	3,118.80	0	0	0	0	0	3,125.58	549.20
Terbufos	1	51.00	2,354.40	0	0	0	0	0	2,405.40	2,263.00
Picloram	1	0	4.80	1,730.88	14.40	12.00	0	0	1,762.08	1,432.00
Diquat	1	57.00	1,424.52	21.00	0	0	0	138.17	1,640.69	266.00

Table 50: continued…

Active Ingredient	Tally	Region							Total Sales/Use	Change in amount
		Vanc. Is.	Lower Mainland	Southern Interior	Kootenay	Cariboo	Skeena	Peace-Omineca	in 1999 (kg)	sold in 1991 (kg)
Chlormequat	1	33.12	1,345.42	9.25	0	0	0	0	1,387.79	555.00
Acephate	1	76.50	1,196.85	73.40	0	0	0	0	1,346.75	543.00
Bentazon	1	33.28	1,142.72	0	0	0	0	138.24	1,314.24	-118.60
Vinclozolin	1	19.20	508.80	0	0	0	0	0	528.00	528.00
Borax, all forms	1	0	482.38	0	0	0	0	0	482.38	423.00
Dodemorph-acetate	1	49.20	425.20	5.60	0	0	0	0	480.00	426.00
Carbofuran	1	7.68	451.20	11.52	0	0	0	7.68	478.08	542.60
Thiram	1	3.84	388.65	27.81	0	0	0	6.67	426.97	67.30
Prometryne	1	0	275.20	9.60	0	0	0	0	284.80	-42.00
Piperonyl butoxide	1	1.84	225.65	5.43	0.69	2.87	0	8.53	245.01	106.00
Imidacloprid	1	0.48	28.68	159.12	0	0	0	0	188.28	188.00
0-benzyl-p-chlorophenol	1	0.68	133.82	8.17	0	0	0	0	142.67	111.38
Dichlorvos	1	0.41	135.80	1.12	0.08	0	0	0	137.41	6.90
Methomyl	1	0.02	101.65	25.98	0	0.02	0	0.41	128.08	-217.80
Fenbutatin oxide	1	2.25	60.00	16.50	0	0	0	0	78.75	-128.00
1-cyhalothrin or cyhalothrin lambda	1	0	10.16	3.04	0.10	0	0	63.68	76.98	77.00
Dinoseb	1	0	48.00	0	0	0	0	0	48.00	-7,185.00
Deltamethrin	1	0.30	28.98	3.75	0	0	0	0.76	33.79	3.10
Amitraz	1	0	0	32.66	0	0	0	0	32.66	32.70
Methoprene	1	0	27.13	0	0	0	0	0	27.13	-77.40
Fenthion	1	0	0.30	1.27	0	4.88	0	0.74	7.19	-30.20
Trichlorfon	1	0	0	0	0	0	0	2.30	2.30	-24.50
Fenitrothion*	1	0	0	0	0	0	0	0	0	0
Total Amount by Region		**11,006.41**	**345,580.88**	**167,830.95**	**2,567.28**	**4,611.93**	**206.48**	**58,055.33**	**589,859.26**	
Percent Total		**2%**	**59%**	**28%**	**0%**	**1%**	**0%**	**10%**		

* indicates that the values are for use not sales.

Table 50: continued…

A.I.'s with Low Toxicity

Mineral Oils	Tally	Region							Total Sales/Use	Change in amount
		Vanc. Is.	Lower Mainland	Southern Interior	Kootenay	Cariboo	Skeena	Peace-Omineca	in 1999 (kg)	sold in 1991 (kg)
Mineral Oil (insecticidal or adjuvant)	1	1,277.10	16,618.88	240,121.44	3,827.71	0	0	0	261,845.13	99,600.00
Mineral Oil (Herbicide/Plant growth reg.)	1	0	35,260.00	0	0	0	0	0	35,260.00	-3,280.00
Mineral Oil (Paraffin Based)	1	132.80	3,572.80	45.20	0	0	0	3,515.05	7,265.85	-333.00
Soap (insecticidal)	1	137.36	2,215.22	1,235.90	10.10	0	0	0	3,598.58	2,566.00
Total Amount by Region		1,547.26	57,666.9	241,402.54	3,837.81	0	0	3,515.50	307,969.56	
Percent Total		0.5%	19%	78%	1.2%	0	0	1.1%		

A.I's representing microbials

Wood Preservatives and Anti-Sapstains	Tally	Region							Total Sales/Use	Change in amount
		Vanc. Is.	Lower Mainland	Southern Interior	Kootenay	Cariboo	Skeena	Peace-Omineca	in 1999 (kg)	sold in 1991 (kg)
Creosote	2	0	1,159,098	3,673,177	0	555,486	0	0	5,387,761	3,142,050
Chromated copper arsenate (CCA)	2	0	360,730	43,261	223,168	171,636	125,192	0	923,987	272,853
Didecyl dimethyl ammonium (DDAC)	2	174,427	114,023	3,757	0	0	17,837	0	310,044	~309,654
Pentachlorophenol	3	0	55,603	0	108,691	37,349	0	0	201,643	-587,467
Iodocarb (IPBC)	2	16,938	9,297	0	0	0	334	0	26,569	~26539
Total Amount by Region		191,365	1,698,751	3,720,195	331,859	764,471	143,363	0	6,850,004	
Percent Total		2.8%	25%	54%	4.8%	11%	2%	0		

APPENDIX G
SELECT LIST OF PUBLICATIONS ON PESTICIDES IDENTIFIED AS A POTENTIAL CONCERN TO AQUATIC BIOTA

Table 51: Select list of publications on pesticides identified as a potential concern to aquatic biota.

Active Ingredient	Species	Affect	Reference
2,4-D	Juvenile sockeye salmon (*Oncorhynchus nerka*)	Stress response	(McBride *et al.* 1981)
4-Nonylphenol, aminocarb	Atlantic salmon (*Salmo salar*)	Synergistic effect on smoltification; endocrine disruption	(Fairchild *et al.* 1999; Fairchild *et al.* 2002)
Aminocarb, nonylphenol, 585 oil	Juvenile Atlantic salmon (*Salmo salar*), freshwater clam (*Anodonta cataractae*), marine shrimp (*Crangon septemspinsa*), lobsters (*Homarus americanus*) and soft-shelled clam (*Mya arenaria*)	Lethality	(McLeese *et al.* 1980)
Atrazine	Atlantic salmon (*Salmo salar*)	Lower fill Na+K+ATPase activity and plasma ion conentraions; delay or inhibit smolt migration	(Fairchild *et al.* 2002)
Basacid Blue NB755; 2,4-D, glyphosate, triclopyr	Juvenile Pacific NW salmonids	Acute toxicity	(Wan *et al.* 1991)
Carbaryl	Brook trout (*Salvelinus fontinalus*) Rainbow trout (*Salmo gairdneri*)	Brain Cholinesterase (ChE) Inhibition	(Haines 1981) (Zinkl *et al.* 1987)
Carbaryl, chlordane, dimethylamine salt of 2,4-DMA, tributyl phosphorotrithioate, methyl parathion, and pentachlorophenol	Rainbow trout (*Oncorhynchus mykiss*)	Behaviour: spontaneous swimming activity, swimming capacity, feeding behaviour, vulnerability to predation	(Little *et al.* 1990)
Carbofuran	Atlantic salmon (*Salmo salar*)	Sublethal effects on pheromonal mediated endocrine function	(Waring and Moore 1997)
Carbofuran, methiocarb, oxyamyl, aldicarb, chlorpyrifos, diazinon, dicrotophos, dimethoate, disulfoton, famphur, fenamiphos, fensulfothion, fenthion, fonofos	Wildlife including various birds and mammal species	Pesticide-related wildlife mortality incidents identified with specific OP and carbamate pesticides	(Glaser 2001)
DDD, DDT, PCB Chlorophenols including pentachlorphenol	Starry flounder (*Platichthys stellatus*)	Levels of bioaccumulation in tissues	(Rogers and Hall 1987)

Table 51: continued…

Active Ingredient	Species	Affect	Reference
Chlorothion, malathion, DDVP demeton, dipterex, parathion, diazinon, co-ral, guthion, EPN, di-syston, delnav	Largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), golden shiner (*Notemigonus crysoleucas*), goldfish (*Carassius auratus*), fathead minnow (*Pimephales promelas*)	Brain Acetylcholinesterase (AChE) inhibition	(Weiss 1961)
Chlorpyrifos, azinphos-methyl, carbaryl, ethoprop	Common carp (*Cyprinus carpio*)	Cholinesterase (ChE) Inhibition	(Gruber and Munn 1998)
DDAC	Juvenile Coho salmon (*Onchorynchus kisutch*)	Biochemcial effects and osmoregulatory stress	(Johnston *et al.* 1998)
DDT, chlordane	East Ice Harp Seal (*Phoca groenlandica*) Harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*)	Presence in blubber samples	(Kleivane *et al.* 1997) (Bernt *et al.* 1999)
Diazinon	Salmon species Chinook salmon (*Oncorhynchus tshawytscha*)	Threats to survival various indicators Predation disruption and homing behaviours	(Cox 2000) (Scholz *et al.* 2000)
Diazinon and malathion	Larval Rainbow trout (*Oncorhynchus mykiss*) Rainbow trout (*Oncorhynchus mykiss*)	Neurotoxicity and behavioural measures Behavioural disfunctions correlated to cholinesterase-inhibiting chemicals	(Beauvais *et al.* 2000) (Brewer *et al.* 2001)
Endosulfan	Rainbow trout (*Oncorhynchus mykiss*)	Inhibition of cortisol secretion in dispersed head kidney cells	(Leblond *et al.* 2001)
Endosulfan, chlordane, lindane, dieldrin, PCB, DDT, DDE, and DDD	*Mytilus trossulus*	Bioaccumulative capability	(Johnson and Davis 1996)
Fenitrothion	Atlantic salmon (*Salmo salar*)	Behaviour	(Symons 1973)
Fenitrothion, sumithion	Juvenile Coho salmon (*Oncorhynchus kisutch*)	Behaviour	(Bull and McInerney 1974)

Table 51: continued…

Active Ingredient	Species	Affect	Reference
Glyphosate	Rainbow trout (*Oncorhynchus mykiss*), Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*Onchorynchus kisutch*) Fish and aquatic invertebrates Juvenile Rainbow trout (*Oncorhynchus mykiss*)	Acute toxicity Toxicity Acute avoidance reaction and behaviour responses	(Mitchell *et al.* 1987) (Folmar *et al.* 1979) (Morgan *et al.* 1991)
Guthion, phorate, parathion	Sheepshead minnow (*Cyprinodon variegatus*)	Brain Acetylcholinesterase (AChE) inhibition related to death	(Coppage 1972)
Hexachlorobenzene & Hexachlorocyclohexane	Vancouver Island Marmot	Detected in tissue and blood samples	(Lichota *et al.* 2004)}
Hexachlorobenzene, dieldrin, chlorane, chlorpyrifos, DCPA, endosulfan, trifluralin, PCP, DDT, and aldrin	Largesclae suckers and carp, rainbow and cuttjroat trout, mountain whitefish, smallmoutha nd largemouth bass, yellow perch , and carp	Concentration levels in whole samples and fillets	(Davis *et al.* 1998)
IPBC	Coho salmon (*Onchorynchus kisutch*), rainbow trout (*Oncorhynchus mykiss*), starry flounder (*Platichthys stellatus*), and three aquatic invertebrates: *Daphina magna, Hyalella azteca*, and *Neomysis mercedis*	Lethal and sublethal toxicity	(Farrell *et al.* 1998)

Table 51: continued…

Active Ingredient	**Species**	**Affect**	**Reference**
Malathion, naled, guthion, parathion	Spot fish (*Leiostomus xanthurus*), pinfish (*Lagodon rhomboides*), Atlantic croaker (*Micropogon undulatus*), sheepshead minnow (*Cyprinodon variegatus*) and pink shrimp (*Penaeus duorarum*)	Inhibition of brain AChE activity	(Coppage and Mattews 1974)
Organophosphorus and carbamate compounds	Variety of wildlife	Toxicology	(Smith 1987)
Polychlorinated biphenyls (suite of)	English sole (*Parophyrys vetulus*) and Starry flounder (*Platichthys stellatus*)	Lesions	(McCain *et al.* 1982)
Unidentified organophosphates	Estuarine fish and pink shrimp	ChE inhibition	(Coppage and Mattews 1974)

APPENDIX H
PESTICIDE RESEARCH INITIATIVES AND MONITORING PROJECTS IN THE PACIFIC REGION

RESEARCH INITIATIVES AND MONITORING PROJECTS IN THE PACIFIC REGION

We contacted over 30 researchers to determine research and monitoring initiatives in the Pacific Region. The following is a summary of projects conducted by agency, as well as information obtained from working groups and conferences in 2001 to 2003.

ENVIRONMENT CANADA

Environment Canada has played a significant role in pesticide research within the Pacific Region. The information provided was from numerous individuals within the department.

Mark Sekela – Senior Environmental Quality Scientist, Aquatic Science.
Current monitoring initiatives:

1) Research is underway on the presence of in-use pesticides in the aquatic receiving environment of the Pacific and Yukon Regions using XAD resin. Currently, 10-15 surface water and 10-15 groundwater sites are being sampled for the presence of pesticides. Focus will be on the Lower Fraser Valley in 2003-2004, Okanagan Valley in 2004-2005 and Vancouver Island in 2005-2006. Sampling will be co-ordinated with a more site specific study conducted by Environmental Protection.

Wayne Belzer – Senior Atmospheric Scientist – Chemistry, Atmospheric Science.
Current monitoring initiatives:

1) Currently conducting 'toxics' monitoring in the ambient air. Other cross-Canada studies have been identified: Jules Blais, University of Ottawa; Frank Wania University of Toronto; Tom Harner Metrological Service of Canada, who are collecting integrated long term samples at sites within BC. Dr. Belzer's work has focused on organochlorines, organophosphates, acid-extractables, and herbicides in a generic package. Samples collected were from both dry air and rainfall. A list of pesticides is available by request.
2) Future work will include collaborative work with the Fisheries and Oceans Canada (Institute of Ocean Sciences) for pesticides (2003-2005), and possibly some work in the Okanagan and Kootenays (related to the federal Border Initiative).

Mike Wan – Senior Chemicals Evaluation Scientist, Chemicals Evaluation.
Current research initiatives:

1) Pesticide (in-use) residues of agricultural runoff in the Lower Fraser Valley: 2003/2006.
2) Endosulfan (and historical OC) residues in the aquatic environment of the Lower Fraser Valley; a risk assessment on non-target indicator organisms: 2002-2005.
3) Bromacil and diuron herbicide movement and their leaching potential along railway rights-of-way in coastal BC: 2003-2004.
4) Potential aquatic contamination of glyphosate/AMPA along BC railway rights-of-way 2003-2004.

5) Is currently trying to publish a document which summarizes all of the work the pesticide section of EC has done nationally on pesticide research. This is anticipated to be completed in the near future.

Doug Wilson – Senior Controls Development Scientist, Toxic Chemicals Control Section. (now retired).

Current research initiatives:

1) Determine the exposure and effects of agricultural pesticides used in Canada and in other countries on migratory birds in the Pacific Region.
2) Identification and quantification of residues of pesticides and their degradation products in coastal agricultural and forestry runoff.
3) Research into acute and sub-acute impacts of pesticides and their transformation product field contamination levels on representative non-target indicator organisms such as aquatic invertebrates, salmonids and amphibians.
4) Evaluation of agricultural pesticides loading into amphibian and fishery habitats and impact on both amphibian/salmonid early-life stages and metamorphosis.
5) Research on pesticides levels in the lower Fraser Valley of BC: in groundwater in areas with extensive agricultural activity; in tile drain effluent from agricultural fields; and in hatchery raised cutthroat trout and crayfish in area streams.
6) Exposure and effects of MSMA (monosodium methanearsonate) used in forest management practices for pest control practices, on cavity-nesting insectivorous birds.
7) Examination of behavioural and endocrine effects of birds exposed to in-use pesticides (azinophosmethyl and mancozeb) in combination with DDE.
8) Development of pesticide residue analytical methods for monitoring, research, scientific assessment and enforcement requirements.
9) Research (e.g. persistence, mobility, degradation, environmental exposure, toxicity and risk analysis involving various partners such as Pacific Environmental Science Centre) on regional priority registered pesticides (e.g. endosulfan congeners, diuron, bromacil) under PYR conditions with recommendations to PMRA regarding the need for re-evaluation or de-registration and /or to the province regarding the need for use pattern changes for inclusion into provincial permits and management plans.
10) Research involving Pacific Environmental Science Centre (PESC), Canadian Wildlife Service, Health Canada and PMRA on issues related to endocrine disrupting chemicals and quantification of the atmospheric concentration and deposition of selected pesticides in the Fraser Valley
11) Regional co-operative programs: scientific advise to the province regarding BC pesticides use permit application and Integrated Pest Management; development of guidelines for the protection of fish and fish habitat; pesticide inspection programs to verify compliance with the Fisheries Act and Migratory Birds Convention Act; operation of a network to respond to wildlife die-off investigations; stakeholder task group development and co-ordination for resolution of pesticide use issues including research on non-chemical pest controls; project with BC Agriculture Council to collect and destroy unwanted pesticides; advise to PMRA on research application permits on new pesticides proposed for use in BC; and promote an annual forum for pesticide information exchange.

12) Monitoring of organochlorine pesticides; Osoyoos aquifer (partnership with province); Dezadeash and Liard Rivers, Yukon Territory; and fish from Okanagan and Similkameen Rivers carried out under the Federal-Provincial Water Quality Monitoring Agreement; time trend analysis of environmental concentrations in the Lower Mainland.

FISHERIES AND OCEANS CANADA

Scientists of the Marine Environment and Habitat Science Division have conducted research on a number of contaminant classes, although much past work has focussed on dioxins and furans produced by the pulp and paper industry and through the preservation of wood (Colodey *et al.* 1999; Yunker and Cretney 1995; Lee and Peart 1999; Mikkelson *et al.* 1996). Various reports have been published (Macdonald *et al.* 1992; Yunker *et al.* 1999; Boyd *et al.* 1997). Work on marine mammals has involved the measurement of PCBs, dioxins, furans and organochlorine pesticides in harbour seals and killer whales (Simms *et al.* 2000; Ross *et al.* 2000). Current efforts include the development of a temporal trend model for contaminants in killer whales (P.S. Ross and colleagues), an ecosystem-based Strait of Georgia marine mammal food web model (P.S. Ross and graduate student), a contaminant budget for the Strait of Georgia (S. Johannessen and R.W. Macdonald), and the measurement of a variety of 'new' anthropogenic compounds in municipal effluents (M.G. Ikonomou). The measurement of PCBs, dioxins, furans, organochlorine pesticides and other compounds in different salmon species has taken place over the last decade, and continues today. The Department conducts research on pesticides nationally within each federal region funded by the Centre for Environmental Research on Pesticides (CERP). Additional pesticide research is funded by the Pesticide Science Fund (PSF).

Dr. Wayne L. Fairchild - Atlantic Region (Moncton, NB).
Current research/monitoring initiatives:

1) DFO will be looking at herbicides and the effects of mixtures of atrazine and other contaminants (e.g. nonyl phenol) on smoltification processes starting in 2004-2005. This will be a combined field and lab initiative in the Atlantic Region. Mixtures have been shown to affect survival upon entrance of smolts to salt water.
2) Examination of the biological effects of traditional agricultural pesticides (potatoes) on benthic invertebrates and shellfish
3) Effects of newer pesticides that act by interfering with insect physiology (e.g. Ecdysone), and their potential for effects on American lobster (probably early life stages).

Pat Lim - Senior Program Biologist, Habitat & Enhancement Branch (HEB) Water Quality Unit.
Current research/monitoring initiatives:

1) DFO in the Pacific Region participates in more of a referral role for Environment Canada throughout the Pesticide Use Permit Applications (PUPA) process. EC sends HEB applications for which the toxicity of the pesticide being used is high for fish or the application will be near fish habitat. DFO is given time to comment. Included in this is process is also the control of mosquitoes which is of increasing prominence because of the impending arrival of West Nile Virus.

2) HEB has participated in the Wireworm Task Group which examines the control of wireworms particularly in potato crops through the use of pesticides, biological control, pheremone trapping and is presently working with EC on Forest Biodiversity Pesticide Standards concerned with identifying the federal concerns with large-scale forestry pesticide applications.
3) Pat Lim is a representative on the Federal Provincial Toxic Chemicals Committee (FPTCC) and the Toxics Group of the Puget Sound-Georgia Basin International Task Force. This group has been looking at the toxic contaminants in the Georgia Basin and two pesticides have been identified for study: atrazine and endosulfan. There is a DFO Agricultural Focus Group, which have been keeped informed on major pesticide use programs in the province.

HEALTH CANADA

All pesticides (i.e. products designed to manage, destroy, attract or repel pests), that are used, sold or imported into Canada are regulated by Health Canada's Pest Management Regulatory Agency (PMRA). PMRA signed a Memorandum of Understanding (MOU) in 1998 with Environment Canada to faciliate the exchange of information and advice with respect to pest control products. Under the MOU, EC carries out environmental research and monitoring and provides the results to PMRA to assess risks associated with pesticides. By seeking to minimize the risks associated with pesticides, PMRA helps protect human health, safety and the environment. Therefore, PMRA does not conduct any research or monitoring directly, and is solely responsible for the compliance and enforcement of the Pest Control Products Act. Their work is geared towards determining whether pesticides are being sold, imported or used according to their label.

NATURAL RESOURCES CANADA - PACIFIC FORESTRY CENTRE

Dr. Alan Thomson - senior research scientist, and Emery Otvos - entomologist, Pacific Forestry Centre.

Current research/monitoring initiatives:

1) Research at the Pacific Forestry Centre focuses on biological pesticide research.
2) Recent research efforts have focused on the effects of *Bacillus thuringiensis Berliner ssp.* Kurstaki (BtK). Monitoring included: i) the effects on non-target insects in operational spray zones; ii) effects of BtK spray at higher doses and concentration on non-target organisms; and iii) effects of BtK on soil arthropods.

BC MINISTRY OF WATER, LAND AND AIR PROTECTION

The Ministry is responsible for the regulation of the Pesticide Control Act. As indicated by their mandate, MWLAP is also responsible for the development of legislation, regulations, policies and risk assessment for: industrial air, water and land emissions and discharges; non-point source emissions; and, toxics, pesticides and contaminated sites. As well as the regulation of some discharges and emissions through a permitting system. They also monitor and report on water, land and air quality, including regulatory compliance.

In 1998 EC and the BC MWALP (formerly known as the BC Ministry of Environment, Lands and Parks, (BC MELP)) intiated research in the Georgia Basin as part of the Georgia Basin Ecosystem Initiative (GBEI) (Ministry of Water 2003b). Their research was triggered by the impact of urbanization on critical habitat of millions of birds, raptors, and spawning salmon. Their goal was to improve air quality, reduce and prevent of water pollution, conserve and protect habitat and species, and support community-based environmental and sustainability initiatives. Although Fisheries and Oceans Canada and the BC Ministry of Municipal Affairs made significant contributions from the start, in 2000, they both formally joined the Steering and Management Committees. U.S. counterparts are also involved in the initiative due to Trans-boundary issues such as the development of transboundary Airshed Management Plan.

From the above initiative arose three consecutive reports by Environment Canada and BC MELP (now BC MWLAP) on surveys of pesticide sales and use in BC. The 1999 report was contracted out to Enkon Environmental Limited. The three surveys allow a trend to be formulated on pesticide use and sales in BC.

SIMON FRASER UNIVERSITY

Chris Kennedy - Associate Professor, Department of Biological Sciences.
Current research initiatives:

1) Effects of pesticides on olfaction physiology and olfactory-mediated behaviours in fish.
2) Ecologically-relevant sublethal toxicities including reproduction, and bioenergetics in fish.
3) Effects of pesticides on stress physiology in fish.

SIERRA LEGAL DEFENCE FUND

John Werring - Staff Scientist.
Current research initiatives:

1) Over the course of the past four years Sierra has conducted work with various First Nations (Muskamaw Tsawataineuk Tribal Council, Katzie First Nation, Takla First Nation) and Conservation groups (Raincoast Research, Stikine Conservation Society, Greenpeace, SPEC) in challenging the issuance of Pesticide Use Permits (PUPs) to forestry companies who want to spray glyphosate and triclopyr, and CN rail wanting to use diuron.
2) Have reviewed individual PUPs (for content and accuracy). Have also conducted on-site field visits to assess accuracy of maps (ground-truth) provided by spray proponents and to assess whether pesticide spraying was a necessity, in addition to providing expert testimony at Environmental Appeal Board hearings.
3) Field visits indicated that in virtually every instance spray proponents failed to: i) provide accurate inventories of streams and watercourses in areas proposed for spraying; ii) adequately assess wildlife use of the areas; iii)
4) adequately consider methods to prevent pesticides from entering watercourses and; iv) in many cases, actually over-sprayed unidentified watercourses and ditch lines.

5) In addition, during field visits, Dr. Werring determined that in many instances where forest companies wanted to spray pesticides, spraying was NOT necessary because the trees in the proposed spray area had already reached free-to-grow status.
6) As for current monitoring activity, very little is being done by the NGO community (or by the spray proponents for that matter) due to the lack of available funding. It is often expensive and difficult (but necessary) to do on-sites in remote areas and the problem cannot be tackled from an armchair assessment of some documents.

GREATER VANCOUVER REGIONAL DISTRICT (GVRD)

Stan Bertold - superintendent of the Environmental Monitoring and Quality Control
Current research/monitoring initiatives:

1) The GVRD currently characterizes and quantifies levels of organochlorine pesticides in GVRD wastewater treatment plant (WWTP) effluents every five years for each of GVRD's five WWTPs. Typically, four surveys are conducted at each plant for a given 5-year cycle of monitoring.
2) Staff characterizes and quantifies levels of organochlorine pesticides in surfial sediments as well as demersal fish and crab collected from the Iona Deep-Sea Outfall study area. Sediments are monitored annually, while fish and crab surveys are conducted on a five-year cycle basis.
3) Regarding WWTP effluents and effluent discharges to the receiving environment, GVRD has had little or no characterization information on pesticides other than the chlorinated type.
4) Have just started to sample and test for pesticides that are not of the organochlorine type. Their interest at this time is whether or not they can detect these pesticides in municipal wastewater. However, these new target pesticides generally lack persistence in the environment.

CAPITAL REGIONAL DISTRICT (CRD)

Celine Larose – Supervisor, Marine Programs.
Current research/monitoring initiatives:
An exploratory survey was conducted in 2000 to investigate whether pesticides could be detected in stormwater discharges (water and sediments) around the Saanich Peninsula. Results from this survey only showed one or two pesticides present in sediment and water at levels just above the detection limits. A second survey was conducted in 2002 to collect water and sediment samples from creeks and rivers that discharge to the marine environment (i.e., sampled the same stormwater discharges as in 2000 but further upstream to see if potential sources of pesticides could be detected). The only pesticide that was detected during the 2002 survey in one discharge was glyphosate. Results from the 2000 and 2002 surveys are presented in the yearly Saanich Peninsula Stormwater Quality Survey reports available from the CRD. No additional surveys are planned. Emphasis has been placed on educating the general public on alternatives to pesticides. A guide for this purpose was produced and is available on the CRD website.

Jody Watson - Victoria and Esquimalt Harbours Environmental Action Program (VEHEAP).
Current research/monitoring initiatives:
Conducted study in the summer of 2002 in Esquimalt Lagoon for the presence of a suite of pesticides in twenty two sample sites. Results showed that pesticides detected were within acceptable levels (Hull and Miller 2000).

CITIES AND MUNICIPALITIES

Green Communities

Since a landmark decision by the Supreme Court of Canada in June of 2001, over 50 Canadian municipalities have employed the right to alter bylaws concerning the use of pesticides on public and private property. Campaigns to phase out the use of cosmetic chemical pesticides on lawns have been mounted in many Canadian communities including the BC municipality of Port Moody. The Pesticide Free Naturally campaign is designed to facilitate education and awareness about the health and environmental impacts of cosmetic pesticides, and to help homeowners find alternatives to reduce use.

The mission of Green Communities projects is to build sustainable communities through resource conservation, pollution prevention, the adoption of ecologically-sound practices, and encouraging a community-based economy. Some of the participating cities in BC and their initiatives are provided below.

Burnaby – BC

The City of Burnaby is looking to add itself to the growing list of Canadian municipalities that ban the use of cosmetic herbicides on private property. City council supported in principle the idea of restricting the use of herbicides within Burnaby. The city is not talking about banning the use of pesticides to control insects, fungicides that keep fungi in check or rodentcides that target rodents. The restriction will only apply to herbicides. The city is looking for feedback on the issue to gauge public support for herbicide reduction before it decides how extensive any restrictions would be. Burnaby is also planning an education program targeted towards homeowners, commercial users, vendors, landscape and industrial herbicide users. The program aims to educate people on the effects of herbicide uses, while providing alternatives. There is also talk of adding a new category to the city's annual environmental awards, one recognizing herbicide-free landscaping. The city has not set a timeline for implementing the ban.

Port Moody - BC

Port Moody was the first municipality in western Canada to take action against pesticides for cosmetic use. In a motion passed unanimously, Port Moody councillors voted to begin a three-year education campaign to teach residents about the risks of pesticide use and possible alternatives. At the end of that period, a bylaw will be drafted to prohibit so-called cosmetic pesticide use. Subsequently this bylaw has been passed. Source - Karen Gram - Vancouver Sun.

Salmon Arm - BC

The Green Shuswap Committee has approached the municipal council, which has passed a resolution (June 2001) "to bring forward a program and policy to eliminate the application of pesticides on public land with a view to eventually eliminating the application of pesticides on private property". Green Shuswap is working closely with the District management to bring forward the program. (http://sunwave.net/green/).
NGO Contact: Eugene Lalonde (Coordinator) - Green Shuswap, Vancouver – BC.

Nanaimo – BC

In 2002, Green Communities Nanaimo launched a pesticide reduction campaign – Pesticide Free Naturally. Campaign objectives include: i) to build awareness among the general population of health and environmental impacts of pesticide use in homes and gardens; ii) to provide concerned citizens with the information they need to use non-toxic methods of pest control in the home, yard, and garden; and iii) to encourage neighbourhood discussion about pesticide use and alternatives and to make reducing pesticide use a matter of individual and neighbourhood pride.

Victoria – BC

A draft bylaw is being developed by the Capital Regional District that will be made available to the 13 member municipalities in the region for eventual adoption. So far, the City of Victoria and the District of Saanich, the two largest municipalities in terms of population, are making progress and have some level of political commitment to pursuing bylaws.
NGO Contact: Cory Waters (Manager) - City Green, Victoria – BC (cwaters@citygreen.ca).

Vancouver – BC

In the January 2003 Report to Council, the Parks and Environment Advisory Committee reviews and recommends actions for reducing the use of cosmetic pesticides within the Municipality, focusing on the use of herbicides, fungicides and insecticides for the mainly aesthetic appearance of lawns and gardens. The municipality of West Vancouver does not use any pesticides in their parks and open space areas, including playfields. With the exception of two golf courses and a nursery, which are a part of an integrated pest management program.

APPENDIX I
CHEMICAL CHARACTERISTICS AND PHYSICAL PROPERTIES OF PESTICIDES IDENTIFIED AS A CONCERN TO THE DFO PACIFIC REGION

NOTE: the majority of the information obtained throughout this section was from EXTOXNET (http://ace.orst.edu/info/extoxnet/.), the Compendium of Pesticide Common Names (http://www.hclrss.demon.co.uk/), and the PMRA ELSE (Electronic Label Search and Evaluation) search engine (http://www.eddenet.pmra-arla.gc.ca/4.0/4.01.asp).

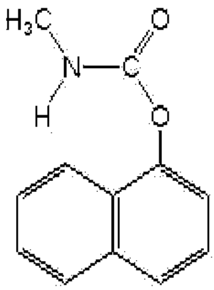
INSECTICIDES

Pesticide: ***BACILLUS THURINGIENSIS*** **(BT)**

Chemical Structure: not applicable
Chemical Class: biological
CAS Registry Number: 68038-71-1
Trade Names: Acrobe, Bactospeine, Berliner (variety kurstaki), Certan (variety aizawai), Dipel, Javelin, Leptox, Novabac, Teknar (variety israelensis), Thuricide, and Victory. Also, Vectobac, Aquatreat, Novodor, Safer's, Preventol, Foray, Bioprotec, Aquabac
Regulatory Status: This microbial insecticide was originally registered in 1961 as a General Use Pesticide (GUP). It is classified as toxicity class III - slightly toxic. Products containing Bt bear the Signal Word CAUTION because of its potential to irritate eyes and skin.
Breakdown Products: unknown
Half Life: 4 months in soil
Water column = can be effective for up to 48 hours in water. Afterwards, it gradually settles out or adheres to suspended organic matter.
Water Solubility: not applicable
Formulation: wettable powders, spray concentrates, liquid concentrates, dusts, baits, time release rings.
Acute Toxicity: Bt is practically nontoxic to fish. Rainbow trout and bluegills exposed for 96 hours to Bt at concentrations of 560 and 1000 mg/L did not show adverse effects. A small marine fish (*Anguilla anguilla*) was not negatively affected by exposure to 1000 to 2000 times the level of Bt expected during spray programs. Field observations of populations of brook trout, common white suckers, and smallmouth bass did not reveal adverse effects 1 month after aerial application of Bt formulation. However, shrimp and mussels may be affected adversely.
Uses: Mosquito, black fly and spruce budworm control.
Basic Manufacturer: Sandox Agro Inc., Abbott Laboratories Ltd., and Chem. And Agric. Prod. Div.

Pesticide: CARBARYL

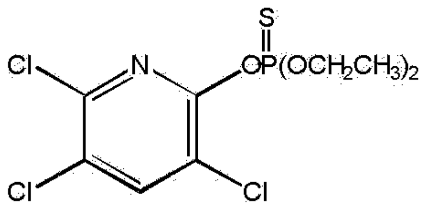
Chemical Structure: 1-naphthalenyl methylcarbamate



Chemical Class: carbamate
CAS Registry Number: 63-25-2
Trade Names: Adios, Bugmaster, Carbamec, Carbamine, Crunch, Denapon, Dicarbam, Hexavin, Karbaspray, Nac, Rayvon, Septene, Sevin, Tercyl, Torndao, Thinsec, Tricarnam, and Union Carbide 7744.
Regulatory Status: In the USA, carbaryl is a General Use Pesticide (GUP). However, various formulations vary widely in toxicity.
Breakdown Products: 1-naphthol
Half Life: 7-14 days in laomy soil; 14-28 days in clay loam soil.
Water column = 10 days, varies with water acidity.
Water Solubility: 113.0 mg/L
Kow: 2.35
Vapor Pressure: <5.3mPa @ 25°C
Adsorption Coeffiecent: 300 mg/L
Formulation: $C_{12}H_{11}NO_2$; baits, dusts, wettable powders, granules, dispersions and suspensions.
Acute Toxicity: moderately toxic to fish LC50 = 1.3mg/L rainbow trout; 10mg/L bluegill. Bioaccumulation can be significant in waters below neutral. Some accummulation can occur in catfish, crawfish, snails, algae and duckweed. Residue levels in fish were 140 fold greater than the concentration of carbaryl in water.
Uses: forestry applications, urban, and agriculture: cherry trees, all cereal crops and grasses for forage.
Basic Manufacturer: Rhone-Poulec Ag. Co.
Notes: Degrades in soil due to sunlight and bacterial action; low leachability. Binds to organic matter and transports in soil runoff. Historically detected in groundwater samples in parts of California.

Pesticide: CHLORPYRIFOS

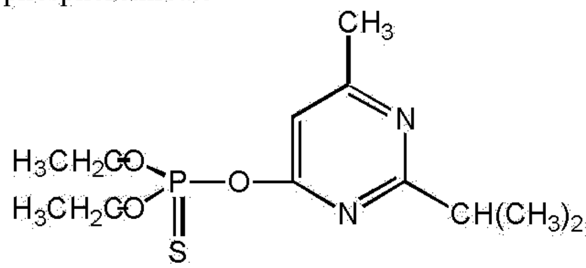
Chemical Structure: 0,0-diethyl 0-(3,5,6-trichloro-2-pyridyl) phosphorothioate



Chemical Class: Organophosphate
CAS Registry Number: 2921-88-2
UN #: 2783
Trade Names: Brodan, Detmol UA, Dowco 170, Dursban, Empire, Eradex, Lorsban, Paqeant, Pirdanes, Scout, Stipend, ENT 27311, OMS 971, Cyren TC, Dur-O-Cap, Pkylrifox, Super Brand D, Strikeforce, Reside, Killmaster II, Pestban, Pryinex, Nufos, Navigator, Chlorpyrifos, chlorfos, Pilot, Equity, Lentrek, Ditox, Termiticide T/C
Regulatory Status: EPA/ WHO Toxicity class II –moderately toxic
Breakdown Products: 3,5,6-trichloro-2-pyridinol (TCP); Carbon dioxide and organic matter
Half Life: 11-141 days in soil Average 30 days
Water column = <1 day
Water Solubility: 2 mg/L @ 25°C
Kow: 4.6990
Vapor Pressure: 2.5 mPa @ 25°C
Adsorption Coeffiecent: 6070 mg/L
Formulation: granules, wettable powder, dustable powder, and emulsifiable concentrate.
Acute Toxicity: LD50 = 135mg/kg
Uses: Broad spectrum insecticide. Liquid termite barriers, lawn granules/sprays, household aerosols/sprays, animal flea collars, agriculture granules/sprays, broccoli, cauliflower, brussel sprouts, cabbage, all cereal crops, canola and rapeseed.
Basic Manufacturer: DowElanco

Pesticide: DIAZINON

Chemical Structure: 0,0-diethyl 0-[6-methyl-2-(1-methylethyl)-4-pyrimidinyl] phosphorothioate

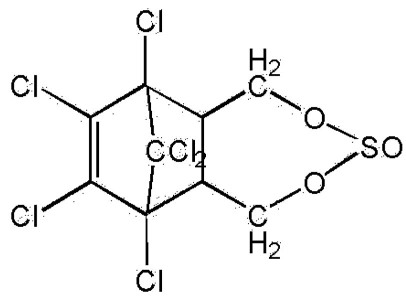


$C_{12}H_{21}N_2O_3PS$
Exact Mass: 304.10
Mol. Wt.: 304.10
C, 47.36; H, 6.95; N, 9.20; O, 15.77; P, 10.18; S, 10

Chemical Class: Organophosphate
CAS Registry Number: 333-41-5
UN # 3018
Trade Names: Knox Out, Spectracide, Basudin, Dazzel, Gardentox, Kayazol, Nucidol,In formulation with pyrethrins, lindane, disulfoton, Diazinon,, Diasol, Drexel
Regulatory Status: EPA/WHO Toxicity class II –moderately toxic. Restricted Use Pesticide (RUP)
To be phased out by Dec. 31, 2004, by PMRA
Breakdown Products: unknown
Half Life: Natural water = 5-15 days
Soil and groundwater = 2-4 weeks
Water Solubility: 40 mg/L @ 20°C
Kow: 3.86
Vapor Pressure: 0.097 mPa @ 25°C
Adsorption Coeffiecent: 1000 mg/L
Formulation: dust, granules, seed dressings, wettable powder, and emulsifiable solution formulations.
Acute Toxicity: WHO LD50 = 1000mg/kg, Extoxnet LD50 = 300-400mg/kg for technical grade in rats.
Uses: Domestic purposes (home, lawn and garden). Control cockroaches, silverfish, ants and fleas in residential buildings; home gardens and farms on leaf insects; rice, fruit trees (cherries and apples), berries (currants, cranberries, raspberrys, grapes), corn, tobacco, potatoes, carrots, broccoli, cauliflower, brussel sprouts, cabbage, horticulture plants; pest strips; veterinary uses – fleas and ticks.
Basic Manufacturer: Ciba-Geigy Corp

Pesticide: ENDOSULFAN

Chemical Structure: 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzadioxathiepin 3-oxide



$C_9H_6Cl_6O_3S$
Exact Mass: 403.82
Mol. Wt.: 403.82
C, 26.57; H, 1.49; Cl, 52.27; O, 11.80; S, 7.

CAS Registry Number: 115-29-7 (alpha-isomer, 959-98-8; beta-isomer, 33213-65-9)
UN # 2761
Chemical Class: Chlorinated hydrocarbon, acaricide
Trade Names: Afidan, Beosit, Cyclodan, Devisulfan, Endocel, Endocide, Endosol, FMC 5462, Hexasulfan, Hildan, Hoe 2671, Insectophene, Malix, Phaser, Thiodan, Thimul, Thifor, Thiosulfan and Thionex.
Regulatory Status: EPA –Toxicity class I, Restricted Use Pesticide (RUP), WHO Toxicity class II –moderately toxic
Breakdown Products: endosulfan sulfate
Half Life: Soil and groundwater = 50 days, moderately persistent; sediment = 1600 days.
-does not dissolve in water, broken down by fungi and bacteria, mobile by surface runoff.
River water = 4 weeks
Basic water conditions = 5 months
Air = 2 days
Plant = 3-7 days
Water Solubility: 0.32 mg/L @ 22°C
Kow: 3.5
Vapor Pressure: 1200 mPa @ 80°C
Adsorption Coeffiecent: 12,400 mg/L
Formulation: emulsifiable concentrate, wettable powder, ultra-low volume (ULV) liquid, and smoke tablets.
Acute Toxicity: Endosulfan is very highly toxic to four fish species and both of the aquatic invertebrates studied; in fish species, the reported 96-hour LC50 values were (in ug/L): rainbow trout, 1.5; fathead minnow, 1.4; channel catfish, 1.5; and bluegill sunfish, 1.2. In two aquatic invertebrates, scuds (*G. lacustris*) and stoneflies (*Pteronarcys*), the reported 96-hour LC50 values

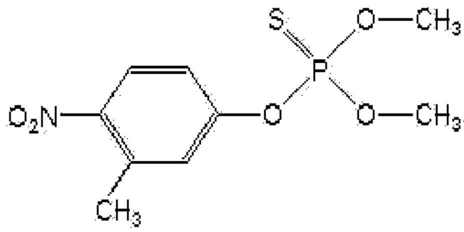
were 5.8 ug/L and 3.3 ug/L, respectively. The bioaccumulation for the compound may be significant; in the mussel (*Mytilus edulis*) the compound accumulated to 600 times the ambient water concentration.

Uses: poison to insects; wood preservative; tree fruits (peaches, apples), berries (strawberry and grapes).

Basic Manufacturer: FMC Corporation; Agricultural Chemicals Group.

Pesticide: FENITROTHION

Chemical Structure: 0,0-dimethyl 0-(3-methyl-4-nitrophenyl) phosphorothioate



Chemical Class: phenyl organothiophosphate
CAS Registry Number: 122-14-5
Trade Names: Accothion, Agrothion, Bay 41831, Cyfen, Cytel, Dicofen, Fenstan, Folithion, Kaleit, Mep, Metathion, Micromite, Novathion, Nuvanol, Pestroy, Sumanone, Sumithion, andVerthion. The common name methylnitrophos is used in Eastern Europe.
Regulatory Status: Fenitrothion is a general use pesticide. Check with specific state regulations for local restrictions which may apply. Products containing fenitrothion must bear the Signal Word CAUTION on their label. Novathion 500-E with malathion is not marketed in the U.S.
Breakdown Products: fenitrooxon, p-nitrocresol and dimethyl phosphorothioic acid.
Half Life: < 1 week in non-sterile muck, sandy loam soils. Intermediately mobile in soils ranging from sandy loam to clay.
Water column = 21.6 (buffered lake water) and 49.6 (natural lake water) days at 23°C pH 7.5 in the dark. 1.5-2.0 days in a model water system.
Water Solubility: 30 mg/L @20°C; 14 mg/L @ 30°C
Kow: n/a
Vapor Pressure: 18 mPa @ 20°C
Adsorption Coeffiecent: unknown
Formulation: $C_9H_{12}NO_5PS$; dust, emulsifiable concentrate, flowable, fogging concentrate, granules, ULV, oil-based liquid spray, and wettable powder formultaions. It is available as a 95% concentrate, 50% emulsifiable concentrate, 40% and 50% wettable powder and 2%, 2.5%, 3% and 5% dusts.
Acute Toxicity: The time for achieving the highest levels of uptake and the extent of retention of organophosphate residues by fish was directly related to the extent of persistence of a compound in water. Motsugo fish exposed to 0.6-1.2 mg/L of fenitrothion attained the highest body concentrations (162 mg/kg) after 3 days. Fenitrothion (4.9 mg/kg) persisted longer than 4 weeks in fish. Fenitrothion is considered somewhat toxic to fish. The 96-hour LC50 was 1.7 ppm for brook trout and 3.8 ppm for bluegill sunfish; moderately toxic to both warmwater and coldwater fish. The 96-hour LC50 to various species of North American freshwater fish has also been reported as 2-12 ug/L. The chronic toxicity of fenitrothion to fish is considered low. The 48-hour LC50 values for carp ranged between 2.0 mg/L and 4.1 mg/L. One source stated that aerial spraying of fenitrothion at 2 or 3 oz/acre on New Brunswick forests has been reported to have no deleterious effect on fish in streams in the treated area. In a study on the acute toxicity of fenitrothion to rainbow trout, embryos were found to be the least sensitive, the sacfry stage was

intermediate, and fingerlings and adults were the most sensitive. The toxicity of fenitrothion to rainbow trout increased with increasing temperature. The sublethal effects of fenitrothion exposure on fish include:

- **Morpho Anatomical Changes:** Swelling of the abdomen of fathead minnows occured. Young Atlantic salmon exposed to 1 mg/L swam with distended fins.

- **Behavioral Changes:** There was a pronounced decline in various agonistic behaviors (chasing, vacating, nipping, etc.) within 2 hours of exposure to several concentrations of fenitrothion. Comfort behaviors (flicks, thrusts, etc.) increased with increasing concentration of toxicant, but declined at higher concentration. Altered station selection occured. At higher concentrations, some fish were unable to maintain position and were swept downstream. After a 5-hour exposure, fish swam near the surface with bloated stomachs and heads pointing downward. Movement was slowed so much that Atlantic salmon did not attempt to avoid capture with a dipnet. *Salmon parr* exposed to 1 mg/L fenitrothion were more vulnerable to predation by brook trout.

- **Biochemical Changes:** Acetylcholinesterase activity was inhibited 13% to 25% after various sublethal concentrations of fenitrothion. Cholinesterase activity in the erythrocytes, gills, heart, and serum of rainbow trout was reduced within 1 hour after exposure to fenitrothion.

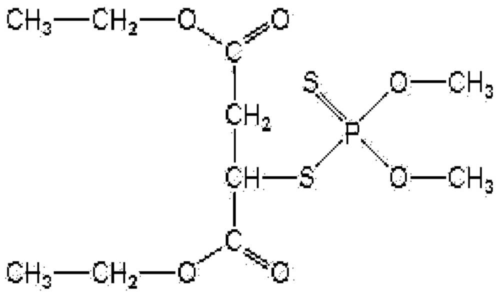
- **Respiratory Effects:** Oxygen consumption of Labeo rohita exposed to fenitrothion progressively decreased with increasing concentrations of insecticide. Exposure caused increased ventilation rate and buccal amplitude at concentrations slightly higher than the 48-hour LC50.

- **Effect on Growth:** Orally administrated fenitrothion had no effect on the growth of rainbow trout. The compound is considered very toxic to crustaceans and aquatic insects and has a medium toxicity to aquatic worms. A freshwater invertebrate toxicity (48-hour or 96-hour EC50) reported fenitrothion to be very highly toxic to aquatic invertebrates (3 ppb for *Gammarus fasciatus*).

Uses: Fenitrothion is effective against a wide range of pests, i.e. penetrating, chewing and sucking insect pests (coffee leafminers, locusts, rice stem borers, wheat bugs, flour beetles, grain beetles, grain weevils) on cereals, cotton, orchard fruits, rice, vegetables, and forests. It may also be used as a fly, mosquito, and cockroach residual contact spray for farms and public health programs. This product had no reported uses in 1999 in British Columbia according to the Enkon report.
Basic Manufacturer: CHEMINOVA Agro A/S; Sumitomo Chemical America, Inc.

Pesticide: MALATHION

Chemical Structure: diethyl [(dimethoxyphosphinothioyl)thio]butanedioate

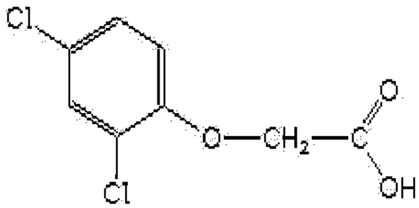


Chemical Class: aliphatic organothiophosphate
CAS Registry Number: 121-75-5
Trade Names: Celthion, Cythion, Dielathion, El 4049, Emmaton, Exathios, Fyfanon and Hilthion, Karbofos and Maltox.
Regulatory Status: Malathion is a slightly toxic compound in EPA toxicity class III. Labels for products containing it must carry the Signal Word CAUTION. Malathion is a General Use Pesticide (GUP).
Breakdown Products: dimethyl phosphate; dimethyldithio phosphate; dimethylthio phosphate; malaoxon; malathion alpha and beta monoacid; o,o-dimethylphosphorordithioic acid; diethyl fumarate; diethyl thiomalate; o,o-dimethylphosphorothionic acid. Mono carboxylic acid; dicarboxylic acid.
Half Life: 1-25 days in soil. Moderately bound to soils and is soluble in water.
Water column = <1 week.
Water Solubility: 143 mg/L @ 20°C
Kow: 2.36
Vapor Pressure: 5.3 mPa @ 30°C
Adsorption Coeffiecent: 1800 mg/L
Formulation: $C_{10}H_{19}O_6PS$; is available in emulsifiable concentrate, wettable powder, dustable powder, and ultra low volume liquid formulations.
Acute Toxicity: LC 50 (96hr) values = walleye 0.06 mg/L; brown trout (0.1 mg/L); cutthroat trout (0.28 mg/L); fathead minnows (8.6 mg/L); goldfish (10.7 mg/L). Various aquatic invertebrates are extremely sensitive, with LC50 values from 1 ug/L to 1 mg/L. Malathion is highly toxic to aquatic invertebrates and to the aquatic stages of amphibians. Because of its very short half-life, it is not expected to bioconcentrate in aquatic organisms. However, brown shrimp showed an average concentration of 869 and 959 times the ambient water concentration in two separate samples.
Uses: control of sucking and chewing insects on fruits and vegetables; mosquitoes, flies, household insects, animal parasites (ectoparasites), and head and body lice. Malathion may also be found in formulations with many other pesticides.
Basic Manufacturer: Drexel Chemical Company.

HERBICIDES

Pesticide: 2,4-D

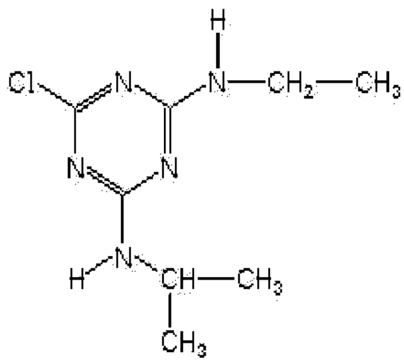
Chemical Structure: (2,4-dichlorophenoxy)acetic acid



Chemical Class: chlorinated phenoxy compound
CAS Registry Number: 94-75-7
Trade Names: Aqua-Kleen, Barrage, Lawn-Keep, Malerbane, Planotox, Plantgard, Savage, Salvo, Weedone, and Weedtrine-II.
Regulatory Status: 2,4-D is a General Use Pesticide (GUP) in the U.S. The diethylamine salt is toxicity class III- slightly toxic orally, but toxicity class I- highly toxic by eye exposure. It bears the Signal Word DANGER - POISON because 2,4-D has produced serious eye and skin irritation among agricultural workers.
Breakdown Products: 2,4-dichlorophenol, other hydroxylic aromatics and polymeric acids.
Half Life: <7 days in soil
Water column = 1 to several weeks
Water Solubility: 900 mg/L @ 25°C (acid)
Kow: 2.81
Vapor Pressure: 0.02 mPa @ 25°C (acid)
Adsorption Coeffiecent: 20 mg/L (acid)
Formulation: $C_8H_6Cl_2O_3$; emulsion form, in aqueous solutions (salts), and as a dry compound.
Acute Toxicity: Some formulations may be more toxic than others LC50 (96 hr) 1.0-100 mg/L in cutthroat trout.
Uses: There are many forms or derivatives of 2,4-D including esters, amines, and salts. 2,4-D is a systemic herbicide and is used to control many types of broadleaf weeds. It is used in cultivated agriculture, in pasture and rangeland applications, forest management, home, garden, and to control aquatic vegetation. In BC, it has a high use rate in cranberry crops and grasses for forage.
Basic Manufacturer: Rhone-Poulenc Ag. Co.

Pesticide: ATRAZINE

Chemical Structure: 6-chloro-*N*-ethyl-*N* -(1-methylethyl)-1,3,5-triazine-2,4-diamine

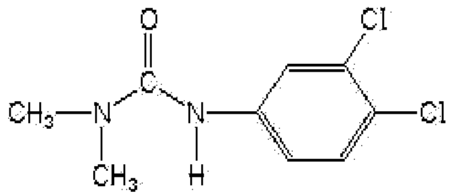


Chemical Class: chlorotriazine
CAS Registry Number: 1912-24-9
Trade Names: Aatrex, Aktikon, Alazine, Atred, Atranex, Atrataf, Atratol, Azinotox, Crisazina, Farmco Atrazine, G-30027, Gesaprim, Giffex 4L, Malermais, Primatol, Simazat, and Zeapos.
Regulatory Status: Atrazine has been classified as a Restricted Use Pesticide (RUP) due to its potential for groundwater contamination. RUPs may be purchased and used only by certified applicators. Atrazine is toxicity class III - slightly toxic. In November, 1994, the EPA initiated a Special Review which could result in use restrictions or cancellation of atrazine if health data warrant such action. Products containing atrazine must the Signal Word CAUTION .
Breakdown Products: hydroxyatrazine; N-Isopropylammelide; cyanuric acid; atarine dealkylated; deethyl hydroxyatrazine; deisopropyl atrazine; deisopropyl hydroxyatrazine; diamnimochlorotriazine; didealkyl atrazine; didealkyl hydroxyatrazine; hydroxyatrazine;(2-chloro-4-ethyl-amino-s-triazine; 2-chloro-4-amino-6-isopropylamino-s-triazine; 2-hydroxy-4-ethylamino-6-isopropyl-amino-s-triazine;2-hydroxy-4-ethylamine-6-amino-s-triazine.
Half Life: > 1 year in soil under dry or cold conditions; highly persistent
Water column = n/a
Moderate to high mobility in soils with low clay or organic content. High potential for groundwater contamination.
Water Solubility: 33 mg/L @ 20°C
Kow: 2.75
Vapor Pressure: 0.039 mPa @ 25°C
Adsorption Coeffiecent: 100 mg/L
Formulation: $C_8H_{14}ClN_5$; dry flowable, flowable liquid, liquid, water dispersible granular, wettable pwdr
Acute Toxicity: slightly toxic to fish low level of bioaccummulation. In whitefish atrazine accumulates in the brain, gall bladder, liver and gut. LC50 (96hr) = 4.5-11.0 mg/L rainbow trout, 76->100 mg/L carp, 16 mg/L bluegill, 15 mg/L Coho, 7.6 mg/L catfish, 4.3 mg/L guppy. LC50 (48h) = 6.1 mg/L Daphnia (21d) = >0.12 mg/L.
Uses: Atrazine is a selective triazine herbicide used to control broadleaf and grassy weeds in corn, sorghum, sugarcane, pineapple, christmas trees, and other crops, and in conifer reforestation

plantings. It is also used as a nonselective herbicide on non-cropped industrial lands and on fallow lands. Highly used on corn crops in BC.
Basic Manufacturer: Ciba-Geigy Corp.
Notes: Air quality testing in two stations in BC found traces in Agassiz and Abbortsford 0.0045 and 0.478 ug/m2/d.

Pesticide: DIURON

Chemical Structure: *N* -(3,4-dichlorophenyl)-*N,N*-dimethylurea

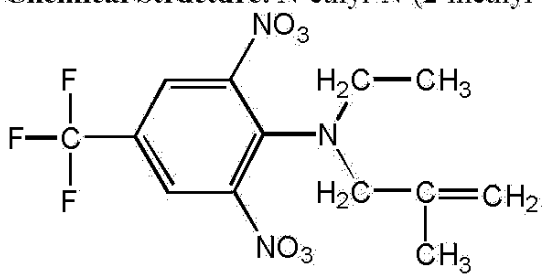


Chemical Class: phenylurea; substituted urea
CAS Registry Number: 330-54-1
Trade Names: Crisuron, Diater, Di-on, Direx, Karmex, and Unidron. It is often used in combination with other pesticides such as bromacil and hexazinone.
Regulatory Status: Diuron is a General Use Pesticide (GUP). The U.S. EPA classifies it as toxicity class III - slightly toxic. However, products containing diuron bear the Signal Word WARNING because it can irritate the eyes and throat.
Breakdown Products: 3,4-dichloroaniline; 3-(3,4-dichlorophenyl)urea; 3-(3,4,dichlorophenyl)-1-methylurea
Half Life: 1 month to 1 year in soil; moderate to high persistence.
Water column = relatively stable in neutral water
Mobility in soil related to organic matter and type of residue.
Metabolites are less mobile than the parent compound. Has been detected in groundwater in Ontario
Water Solubility: 42 mg/L @ 25°C
Kow: 2.67
Vapor Pressure: 0.41 mPa @ 50°C
Adsorption Coeffiecent: 480 mg/L
Formulation: $C_9H_{10}Cl_2N_2O$; wettable powders, suspension concentrates.
Acute Toxicity: LC50 (96hr) = 3.5 mg/L rainbow trout; LC50 (48hr) = 4.3-42 mg/L in fish and 1-2.5 mg/L for aquatic invertes.
Uses: Herbicide used to control a wide variety of annual and perennial broadleaf and grassy weeds, as well as mosses. It is used on non-crop areas especially along railroads.
Basic Manufacturer: DuPont Agricultural Products.

CAN394651_0212

Pesticide: ETHALFURALIN

Chemical Structure: N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)

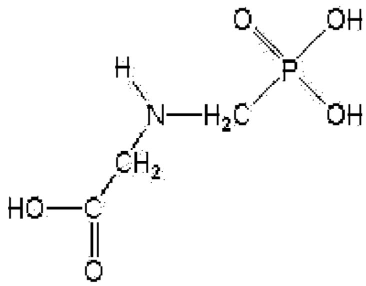


$C_{13}H_{14}F_3N_3O_6$
Exact Mass: 365.08
Mol. Wt.: 365.08
C, 42.75; H, 3.86; F, 15.60; N, 11.50; O, 26.28

CAS Registry Number: 55283-68-6
Chemical Class: Dinitroaniline compound
Trade Names: Sonalan
Regulatory Status: WHO no acute hazard in normal use.
Breakdown Products: N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)benzenamine.
Half Life: sediment 1600 days; binds strongly to soil (~25 -46 days in agricultural soils in various soil types across Canada).
Water =1-2 days
Air = 0.19 days
Water Solubility: 0.3 mg/L @ 25°C
Kow: 5.11
Vapor Pressure: 8.2 mm Hg @ 25°C
Adsorption Coeffiecent: 48 mg/L
Formulation: emulsifiable concentrates, granular, dry flowable.
Acute Toxicity: Highly toxic to aquatic organisms with a moderate bioconcentration potential. LC50 (96hr) = <0.1 ppm to bluegill.
Uses: Ethalfluralin is a selective herbicide used for the pre-emergence control of annual grasses and broadleaf weeds in certain food and feed crops. It may be used in growing a variety of grain, seed, and cucurbit crops. The greatest amounts of ethalfluralin in BC are used in growing fababeans, peas and lentils. Products may be applied pre-plant, post-plant prior to emergence, post-emergence, or post-transplant as a soil incorporated, band, or broadcast application using ground equipment.
Basic Manufacturer: Elanco Products Company; Dow AgroSciences Canada Inc.

Pesticide: GLYPHOSATE

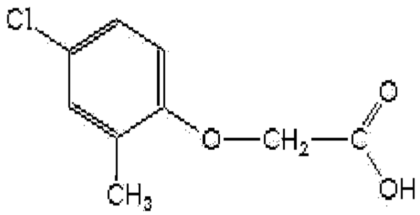
Chemical Structure: *N*-(phosphonomethyl) glycine



Chemical Class: organophosate
CAS Registry Number: 1071-83-6
Trade Names: Gallup, Landmaster, Pondmaster, Ranger, Roundup, Rodeo, and Touchdown. It may be used in formulations with other herbicides.
Regulatory Status: Glyphosate acid and its salts are moderately toxic compounds in EPA toxicity class II. Labels for products containing these compounds must bear the Signal Word WARNING. Glyphosate is a General Use Pesticide (GUP).
Breakdown Products: aminomethylphosphoric acid and others.
Half Life: 47 days in sediment Average 1-17 days
Water column = 12 days to 10 weeks. Strongly adsorbed to suspended organic and mineral matter.
Water Solubility: 12,000 mg/L @ 25°C
Kow: -3.22 to -2.77
Vapor Pressure: negliable
Adsorption Coeffiecent: 24,000 (estimated)
Formulation: $C_3H_8NO_5P$; Glyphosate itself is an acid, but it is commonly used in salt form, most commonly the isopropylamine salt. It may also be available in acidic or trimethylsulfonium salt forms. Generally applied as water-soluble concentrates and powders.
Acute Toxicity: practically non-toxic to fish slightly toxic aquatic invertebrates LC50 (96hr) = 120 mg/L bluegill, 168 mg/L harequin, 86 mg/L rainow trout; LC50 (96hr) = 10 mg/L Atlanic oyster, 934 mg/L fiddler crab, 281 mg/L shrimp; LC50 (48hr)= 780 mg/L Daphina.
Uses: Broad-spectrum, nonselective systemic herbicide used for control of annual and perennial plants including grasses, sedges, broad-leaved weeds, and woody plants. It can be used on non-cropland as well as on a great variety of crops. Intensively used by the forestry sector, industrial applications such as railroads and hydro rights-of-ways, as well as, agricultural and urban applications.
Basic Manufacturer: Monsanto Company.
Notes: It is estimated that less than 2% of chemical applied is lost due to run off.

Pesticide: MCPA

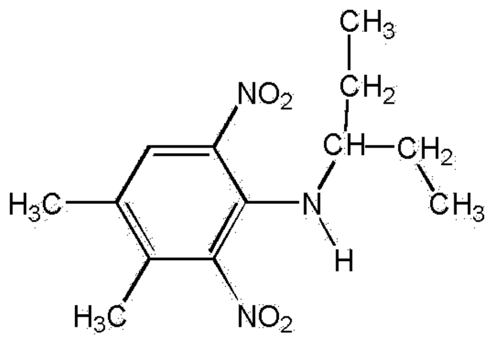
Chemical Structure: (4-chloro-2-methylphenoxy) acetic acid



Chemical Class: phenoxyacetic
CAS Registry Number: 94-74-6
Trade Names: Agritox, Agroxone, Agrozone, Agsco MXL, Banlene, Blesal MC, Bordermaster, Cambilene, Cheyenne, Chimac Oxy, Chiptox, Class MCPA, Cornox Plus, Dakota, Ded-Weed, Empal, Envoy, Gordon's Amine, Kilsem, Legumex, Malerbane, Mayclene, MCP, Mephanac, Midox, Phenoxylene, Rhomene, Rhonox, Sanaphen-M, Shamrox, Selectyl, Tiller, U 46 M-Fluid, Vacate, Weed-Rhap, and Zhelan.
Regulatory Status: MCPA is a slightly toxic compound in EPA toxicity class III, and is a General Use Pesticide (GUP). Labels for products containing MCPA must carry the Signal Word DANGER due to its potential to cause severe eye irritation.
Breakdown Products: 4-chloro-o-cresol; 3-methyl-5-chlorocatechol.
Half Life: 14 days to 1 month in soil depending on organic content.
Water column = 5 weeks
readily leaches in most soils, but its mobility decreases with an increase in organic matter
Water Solubility: 825 mg/L @ 25°C (acid)
Kow: 2.52
Vapor Pressure: 0.2 mPa @ 20°C
Adsorption Coeffiecent: 100 g/L (acid); 20 mg/L (salt); 1000 mg/L (ester)
Formulation: $C_9H_9ClO_3$
Acute Toxicity: slightly toxic to fish LC50= 117-232 mg/L rainbow trout
Uses: Is a systemic postemergence phenoxy herbicide used to control annual and perennial weeds (including thistle and dock) in cereals, flax, rice, vines, peas, potatoes, grasslands, forestry applications, and on rights-of-way. This herbicide is very compatible with many other compounds and may be used in formulation with many other products, including bentazone, bromoxynil, 2,4-D, dicamba, fenoxaprop, MCPB, mecoprop, thifensulfuron, and tribenuron. In BC is highly used in production of legumes for seed and forage; grasses for forage; Spring Wheat; Winter Wheat; Barley; Oats; Rye.
Basic Manufacturer: Gilmore, Inc.

Pesticide: PENDIMETHALIN

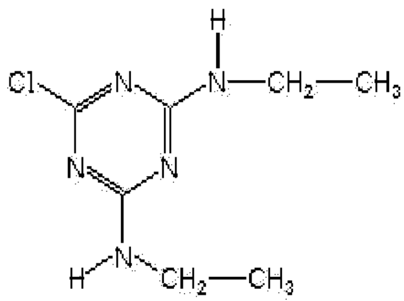
Chemical Structure: N-(1-ethylpropyl)-2,6-dinitro-3,4-xylidine



CAS Registry Number: 40487-42-1
Chemical Class: Dinitroaniline compound
Trade Names: AC 92553, Accotab, Go-Go-San, Herbadox, Penoxalin, Prowl, Sipaxol, Sovereign, Stomp and Way-Up.
Regulatory Status: EPA, Toxicity class III –slightly toxic–General Use Pesticide (GUP)
Breakdown Products: dinitrobenzyl alcohol.
Half Life: moderately persistent, absorbs to soil, insoluble in water, stable to hydrolysis, but degrade in sunlight, absorbed by plant roots
Soil and groundwater = 40 days
Sediment = 540 days
Air – 0.54 days
Water Solubility: 0.3 mg/L @ 20°C
Kow: 4.82
Vapor Pressure: 4.0 mPa @ 25°C
Adsorption Coeffiecent: 5000 mg/L
Formulation: emulsifiable concentrate, wettable powder, or dispersible granule formulations.
Acute Toxicity: LD50=1050 mg/kg; LC50 (96 hr) = 199 ug/L bluegill; 138 ug/L rainbow trout; 420 ug/L channel catfish. LC50 (96 hr) = 280 ug/L *Daphnia magna.* Bioconcentration factor in whole fih is 5100, moderate potential to accumulate in aquatic organisms.
Uses: Control annual grasses and weeds in field corn, rice, cotton, soybean tobacco, peanut, sunflower; cultivation into the soil recommended within 7 days. In BC used predominately on corn crops.
Basic Manufacturer: American Cyanamid.

Pesticide: SIMAZINE

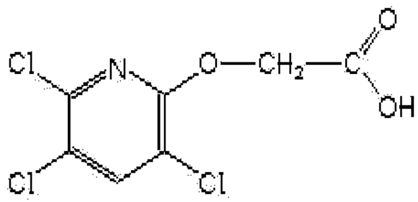
Chemical Structure: 6-chloro-*N,N* -diethyl-1,3,5-triazine-2,4-diamine



Chemical Class: chlorotriazine
CAS Registry Number: 122-34-9
Trade Names: Aquazine, Caliber, Cekusan, Cekusima, Framed, Gesatop, Primatol S, Princep, Simadex, Simanex, Sim-Trol, Tanzine and Totazine. This compound may also be found in formulations with other herbicides such as amitrole, paraquat dichloride, metolachlor, and atrazine.
Regulatory Status: Simazine is a General Use Pesticide (GUP). It is in EPA toxicity class IV - practically nontoxic. Products containing simazine bear the Signal Word CAUTION. In November 1994, the U.S. EPA began a Special Review of simazine which could result in use restrictions or even cancellation if data warrant such action.
Breakdown Products: deethyl-simazine; deethylhydroxysimaine; deisopropyl atrazine; hydroxysimazine.
Half Life: 28 – 149 days in soil Average 60 days.
Water column = 30 days. Actual half life depends on level of algal present, degree of weed infestation, plus other factors.
Water Solubility: 5.0 mg/L @ 20°C
Kow: 1.96
Vapor Pressure: 0.000810 mPa @ 20°C
Adsorption Coeffiecent: 130 mg/L
Formulation: $C_7H_{12}ClN_5$; available in wettable powder, water dispersible granule, liquid, and granular formulations.
Acute Toxicity: Simazine is slightly to practically nontoxic to aquatic species. LC50 (96hrs) >100 mg/L rainbow trout; 100 mg/L (wettable pwdr) in bluegill, 0.100 mg/L fathead minnows and carp. Oysters >3.7 mg/L. It may be more toxic to *Daphia* and stoneflies.
Uses: It is used to control broad-leaved weeds and annual grasses in field, berry fruit, nuts, vegetable and ornamental crops, turfgrass, orchards, and vineyards. At higher rates, it is used for nonselective weed control in industrial areas.
Basic Manufacturer: Ciba-Geigy Corporation.

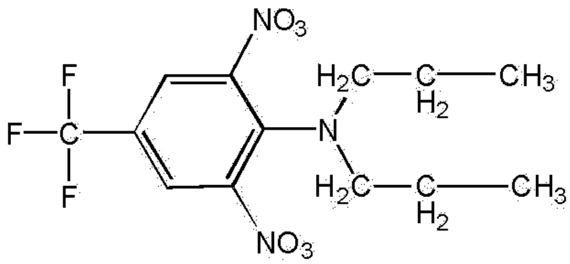
Pesticide: TRICLOPYR

Chemical Structure: [(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid



Chemical Class: pyridine
CAS Registry Number: 55335-06-3
Trade Names: Access, Crossbow, ET, Garlon, Grazon, PathFinder, Redeem, Rely, Remedy, and Turflon.
Regulatory Status: Some or all applications of the product Access may be classified as Restricted Use. Restricted Use Pesticides (RUPs) may be purchased and used only by certified applicators. It is toxicity class III - slightly toxic, but can cause eye irritation. The product will either have the Signal Word DANGER or CAUTION on the label, depending on the specific formulation. Products labeled DANGER include Garlon 3A, Redeem, and Turflon Amine.
Breakdown Products: trichlororpyridinol
Half Life: 46 days in soil Ave. days
Water column = 2.8 – 14.1 hours (amine); 12.5 – 83.4 hours (ester)
Water Solubility: 440 mg/L @ 25°C
Kow: 0.42
Vapor Pressure: 0.168 mPa @ 25°C
Adsorption Coeffiecent: 20 mg/L (amine); 780 mg/L (ester)
Formulation: $C_7H_4Cl_3NO_3$. Triclopyr is commercially available mainly as a triethylamine salt or butoxyethyl ester of the parent compound.
Acute Toxicity: Parent and amine salts practically non-toxic to fish. Amine formulation LC50 (96hr) = 117 mg/L rainbow trout; 148 mg/L bluegill. Ester formulation LC50 (96hr) = 0.74 mg/L and 0.87 mg/L in rainbow and bluegill.
Uses: A selective systemic herbicide used for control of woody and broadleaf plants along rights-of-way in forests, on industrial lands, and on grasslands and parklands. Unlike a similar product, 2,4,5-T, dioxin impurities do not occur in triclopyr.
Basic Manufacturer: DowElanco.

Pesticide: TRIFLURALIN
Chemical Structure: a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine



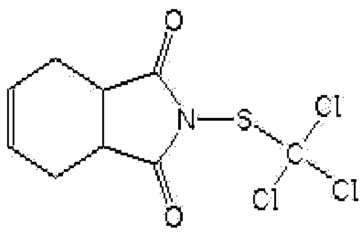
$C_{13}H_{16}F_3N_3O_6$
Exact Mass: 367.10
Mol. Wt.: 367.10
C, 42.51; H, 4.39; F, 15.52; N, 11.44; O, 26.14

CAS Registry Number: 1582-09-8
Chemical Class: Dinitroaniline compound
Trade Names: Crisalin, Elancolan, Flurene SE, Ipersan, L-36352, M.T.F., Su Seguro Carpidor, TR-10, Trefanocide, Treficon, Treflan, Tri-4, Trifluralina 600, Triflurex Trim, and Trust.
Regulatory Status: Products containing trifluralin bear the Signal Words CAUTION or WARNING, depending on the type of formulation. This compound is a General Use Pesticide (GUP) in toxicity class III - slightly toxic. N-nitrosamine contaminant levels in trifluralin are required to be below 0.5 ppm, a level which EPA believes will result in no toxic effects.
Breakdown Products: a,a,a-trifluoro-2,6-dinitro-p-toluidine; a,a,a-trifluoro-2,6-diniro-n-propyl-p-toluidine; a,a,a-trifluoro-N,N-dipropyl-5-nitrotoluene-3,4-diamine; a,a,a-trifluoro-N,N-dipropyltoluene-3,4,5-triamine.
Half Life: Soil = 45-60 days to 6-8 months
Sediment = 1600 days
Water = 180 days
Air = 0.67 days
Water Solubility: <1 mg/L @ 27°C
Kow: 5.07
Vapor Pressure: 13.7 mPa @ 25°C
Adsorption Coeffiecent: 8000 mg/L
Formulation: Granular formulations may be incorporated by overhead irrigation. Trifluralin is available in granular and emulsifiable concentrate formulations. The technical material is approximately 96% pure and the emulsifiable concentrate is about 45% pure.
Acute Toxicity: LD50>10000mg/kg.
Uses: Registered for use to control annual grasses, weeks, fruit trees, grain crops. In BC, it is used mainly by the agricultural sector predominately on beans, broccoli, cauilflower, brussels, cabbage, green peas.
Basic Manufacturer: DowElanco.

FUNGICIDES

Pesticide: CAPTAN

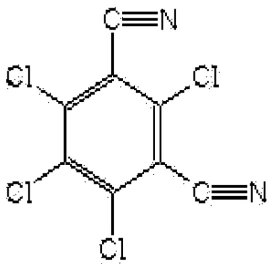
Chemical Structure: 3a,4,7,7a-tetrahydro-2-[(trichloromethyl)thio]-1H-isoindole-1,3(2H)-dione



Chemical Class: phthalimide
CAS Registry Number: 133-06-2
Trade Names: Agrox, Captal, Captec, Captol, Captonex, Clomitane, Merpan, Meteoro, Orthocide, Phytocape, Sepicap, Sorene, and Vancide 89. Captan may be found in formulations with a wide range of other pesticides.
Regulatory Status: Captan is a General Use Pesticide (GUP), though most uses of the compound on food crops were cancelled in the U.S. in 1989. It is categorized as toxicity class IV - practically nontoxic. However, it bears the Signal Words DANGER or CAUTION if packaged in concentrated form because it can be irritating to the skin and eyes.
Breakdown Products: tetrahydrophthalimide.
Half Life: 1-10 days in most soils
Water column = 23-54 hours, residual life in water is 2 weeks.
Water Solubility: 3.3 mg/L @ 25°C
Kow: 2.35
Vapor Pressure: 1.3 mPa @ 25°C
Adsorption Coeffiecent: 200 mg/L
Formulation: $C_9H_8Cl_3NO_2S$; wettable powders, aqueous suspensions, dusts, seed treatment (dust).
Acute Toxicity: Highly toxic to fish. LC50 (96hr) = 0.056 mg/L cutthroat trout and chinook salmon; 0.072 mg/L bluegill. LC50 (96hr) = 7-10 mg/L *Daphnia*. Low to moderate tendency to bioaccummulate.
Uses: Captan is a nonsystemic phthalimide fungicide used to control diseases of many fruit, ornamental, and vegetable crops. It improves fruit finish by giving it a healthy, bright colored appearance. It is used in agricultural production as well as by the home gardener. A major use of captan is in apple production. In BC, captan is used heavily used in the production of blueberry, raspberry, strawberry and bean crops.
Basic Manufacturer: Drexel Chemical Company.

Pesticide: CHLOROTHALONIL

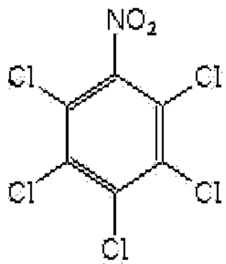
Chemical Structure: 2,4,5,6-tetrachloro-1,3-benzenedicarbonitrile



Chemical Class: chloronitrile
CAS Registry Number: 1897-45-6
Trade Names: Bravo, Chlorothalonil, Daconil 2787, Echo, Exotherm Termil, Forturf, Mold-Ex, Nopcocide N-96, Ole, Pillarich, Repulse, and Tuffcide.
Regulatory Status: Chlorothalonil is classified as a General Use Pesticide (GUP) by the U.S. EPA. It is classified as toxicity class II - moderately toxic, due to its potential for eye irritation. Chlorothalonil containing products have a range of Signal Words, including WARNING (Bravo 720, 500), CAUTION (Exotherm Termil), and DANGER (Bravo W-75, Daconil W-75). Each of these products has a different formulation and product concentration and thus requires a different Signal Word.
Breakdown Products: isophthalonitrile;mono-, di- and tri- chlorinated isophthalonitriles;2,5,6-trichloro-4-hydroxyisophthalonitrile; 2,5,6-trichloro-4-methoxyisophthalonitrile
Half Life: 1-3 months in soil. Increase in soil temperature or moisture increases degradation.
Water column = 10 weeks
high binding and low mobility in silty loam and silty clay loam soils , has low binding and mod mobility in sand.
Water Solubility: 1.0 mg/L
Kow: 20.9
Vapor Pressure: 1.3 mPa @ 40°C
Adsorption Coeffiecent: 1380 mg/L
Formulation: $C_8Cl_4N_2$
Acute Toxicity: Chlorothalonil and its metabolites are highly toxic to fish, aquatic invertebrates, and marine organisms. Fish, such as rainbow trout, bluegill, and channel catfish are noticeably affected even when chlorothalonil levels are low (less than 1 mg/L). The LC50 is 0.25 mg/L in rainbow trout, 0.3 mg/L in bluegills, and 0.43 mg/L in channel catfish. Chlorothalonil does not store in fatty tissues and is rapidly excreted from the body. Its bioaccumulation factor is quite low.
Uses: Chlorothalonil is a broad-spectrum organochlorine fungicide used to control fungi that threaten vegetables, trees, small fruits, turf, ornamentals, and other agricultural crops. It also controls fruit rots in cranberry bogs. In BC, is used heavily on blueberry and cranberry crops, as well as, potato, carrots, broccoli, cauliflower, brussel sprouts, cabbage and peas.
Basic Manufacturer: Crystal Chemical Inter-America.

Pesticide: QUINTOZENE

Chemical Structure: pentachloronitrobenzene

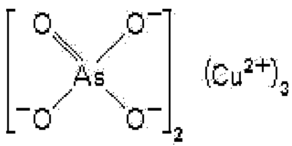


Chemical Class: organochlorine
CAS Registry Number: 82-68-8
Trade Names: Quintozene, is also known as PCNB (Pentachloronitrobenzene). Trade or other names for PCNB or products containing it include Avicol, Botrilex, Brassicol, Earthcide, Folosan, Kobu, Kobutol, Pentachloronitrobenzene, Pentagen, Saniclor, Terraclor, Terrazan, Tilcarex, Tri-PCNB, Triquintam, Tritisan, Tubergran, and Turfcide.
Regulatory Status: Pentachloronitrobenzene is a slightly toxic compound in US EPA toxicity class III. Labels for products containing PCNB must bear the Signal Word CAUTION. Most products containing PCNB have been cancelled for use in the U.S.
Breakdown Products: in soil (pentachloroaniline, pentachlorobenzene, hexachlorobenzene, and pentochlorothioanisole); in plants (pentachloroaniline and methylthiopentachlorobenzene).
Half Life: Sediment = 3 weeks to 1 year more rapid breakdown in sandy soils. Metabolites persist 2-3 years.
Water column = 1.8 to 5 days
unchanged by sunlight, stable in acidic and neutral solutions. Rapidly adsorbed to sediments and suspended solids.
Water Solubility: 0.44 mg/L @ 20°C
Kow: 4.46
Vapor Pressure: 6.6 mPa @ 20°C
Adsorption Coeffiecent: 5000 (estimated)
Formulation: $C_6Cl_5NO_2$ dustable or wettable powder, in granular form, emulsifiable concentrate, and seed treatment.
Acute Toxicity: LC50 (96hr) = 0.55 mg/L rainbow trout; 0.1 mg/L bluegill. Accumulate in aquatic animals and plants.
Uses: A fungicide used as a seed dressing or soil treatment to control a wide range of fungi species in such crops as potatoes, wheat, onions, lettuce, tomatoes, tulips, garlic, and others. Depending on the producer and the manufacturing procedure, PCNB impurities can include hexachlorobenzene, pentachlorobenzene, and tetrachloronitrobenzene. The fungicide is often used in combination with insecticides and fungicides including carbaryl, imazalil, tridimenol, etridiazole, and fuberidazole. Urban use high especially by golf courses and landscaping services.
Basic Manufacturer: Uniroyal Chemical Co., Inc.

MICROBIALS

Pesticide: COPPER CHROMATED ARESENATE (CCA)

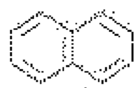
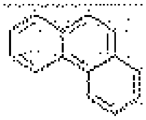
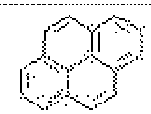
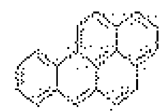
Chemical Structure:



Chemical Class: arsenical
CAS Registry Number: 21-22-6;
Trade Names: Wolmanac, Chemonite, Copper Chem.
Regulatory Status: The wood treatment industry in Canada is making a voluntary transition away from the use of CCA to treat wood for use in residential applications by the end of 2003. Remaining stocks of wood treated with CCA before December 31, 2003 can continue to be sold and used for residential applications. Existing structures built from CCA treated wood are not affected by this action. Currently under re-evaluation by US EPA and Canada's PMRA.
Breakdown Products: copper, arsenic, chromium.
Half Life: unknown
Water Solubility: unknown
Kow: unknown
Vapor Pressure: unknown
Adsorption Coeffiecent: unknown
Formulation: $As_2Cu_3O_8$ plus chromium
Acute Toxicity: This product is toxic to fish and wildlife. Do not apply directly to water.
Uses: Contents for use only in the preparation of wood preservation treating solutions which are to be used only at pressure treating facilities for forest products. Treated wood is provided protection against termites, ascomycetes, brown rot, dry and white rot.
Basic Manufacturer: Chemical Specialties, Inc.

Pesticide: CREOSOTE

Chemical Structure: some examples of PAH chemical structures.

Property	Naphthalene	Phenanthrene	Anthracene	Pyrene	Benzo(a)pyrene
Structure					
Molecular weight	128.2	178.2	178.2	202.3	252.3
Maximum extracted concentration in 1.85% Biosurfactant (mg/L)	938.4	156*	99.8	539.8	42.3
Solubility in water at 25 °C (mg/L)**	31.7	1.29	0.075	0.135	0.0038
Henry's law constant (atm-m³/mol)	$4.27X10^{-4}$	$2.56X10^{-5}$	$1.77X10^{-5}$	$1.14X10^{-5}$	$4.9X10^{-7}$

Chemical Class: Polycyclic aromatic hydrocarbon
CAS Registry Number: 8021-39-4
Trade Names: RECOCHEM, Carbochem, RAM, Pole Wrap.
Regulatory Status: Currently under re-evaluation by US EPA and Canada's PMRA.
Breakdown Products: variety of PAH compounds..
Constituents: napthlalene (17.5%), phenanthrene (10.2%), fluoranthene (9.9%), acenaphthene (5.6%), fluorene (5.1%), pyrene (4.4%), anthracene (2.3%), anthracene (2.3%), carbazole (2.1%), acenapthylene (2.0%), benz(a)anthracene (1.1%), chrysene (1.0%), benzo(b)fluoranthene (0.6%), benzo(k)fluoranthene (0.4%), dibenz(a,h)anthracene (0.2%), benzo(g,h,i)pyrene (0.1%), ideno(1,2,3-c,d)pyrene (0.1%), benzo(a)pyrene (0.1%), acridine, quinoline.
Half Life: Soil = unknown
Sediment = unknown
Water column = unknown
Water Solubility: negliable
Kow: unknown
Vapor Pressure: unknown
Adsorption Coeffiecent: unknown
Formulation: The major constituents of creosote are the polycyclic aromatic hydrocarbons or PAHs. Estimates of the PAH composition in creosote range from 45 to 85%.
Acute Toxicity: The high molecular weight PAHs can be very persistent in the environment and are known to produce both acute and chronic toxicity in aquatic species at sufficiently high concentrations. Low molecular weight PAH compounds are generally the more acutely toxic form, but, certain high molecular weight compounds, or more specifically their metabolites, can be carcinogenic. Other chronic effects, such as impaired immune function, lower survival and reproductive rates and certain biochemical responses have also been demonstrated in juvenile Chinook salmon (Varanasi *et al.*, 1993), impaired reproduction, biochemical changes, and

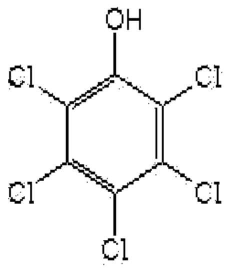
presence of hepatic lesions in flatfish (Myers *et al.*, 1987). The biological effects from PAHs in the marine environment have also been documented by Malins *et al.*, (1985); Varanasi *et al.*, (1989) and Johnson *et al.*, (1994).

Uses: Creosote, a distillate of coal tar, has been used for over a century as a wood preservative. It is widely used throughout North America in the construction of piers, wharves and other maritime structures for protection against attack by marine borers, greatly extending their service life, up to 75 years or more.

Basic Manufacturer: VFT Canada Inc.; Farwest Chemicals; North Star Structural Contractors Ltd.; Recochem Inc., RAM Brand Div.

Pesticide: PENTACHLOROPHENOL

Chemical Structure:



Chemical Class: chlorinated hydrocarbon
CAS Registry Number: 87-86-5
Trade Names: Dowicide, PCP, Penchlorol, Penta, Penta Plus, Pentachloral, Pentacon, Penwar, Priltox, Santobrite, Santophen, Sinituho, and Weedone.
Regulatory Status: Banned product in BC, however is still in use although no new sales since 1991. Currently under re-evaluation by US EPA and Canada's PMRA.
Breakdown Products: unknown
Half Life: 45 days in soil Average days
Water column ranges from a couple of hours to days.
Water Solubility: 80 mg/L @ 20°C
Kow: 5.12
Vapor Pressure: 16,000 mPa @ 20°C
Adsorption Coeffiecent: 30 mg/L (estimated)
Formulation: C_6HCl_5O; blocks, flakes, granules, liquid concentrates, wettable powders, or ready-to-use petroleum solutions.
Acute Toxicity: PCP may be highly to very highly toxic to many species of fish; LC50 (96 hr) = 68 ug/L chinook salmon; 52 ug/L rainbow trout; 205 ug/L fathead minnow; 68 ug/L channel catfish; and 32 ug/L in bluegill sunfish. Several species of fish, invertebrates, and algae have had levels of PCP that were significantly higher (up to 10,000 times) than the concentration in the surrounding waters. Once absorbed by fish, pure PCP is rapidly excreted as is its metabolite, with a biological half-life of only 10 hours. Biomagnification, that is the progressively higher concentration of a compound as it passes up the food chain, is not thought to be significant because of PCP's rapid break down in living organisms.
Uses: PCP is primarily used to protect timber from fungal rot and wood-boring insects. Technical grade PCP has historically contained dioxins (e.g. tetra-, hexa- and octochlorodibenzo-p-dioxin) and hexachlorobenzene as manufacturing by-products. Technical grade PCP is typically about 86% pure. The discovery of these compounds in technical grade PCP may be one reason for its being phased out of use. Pentachlorophenol is also a major product of the metabolism of hexachlorobenzene in mammals.
Basic Manufacturer: ISK Biosciences.