

DRAFT

**A REVIEW OF ECOLOGICAL EFFECTS OF BIOCIDES PROPOSED FOR  
USE IN FSC CERTIFIED FORESTS OF THE NORTHEAST UNITED STATES  
AND EASTERN CANADA**

Prepared by: Yuka Ota and Charles Restino  
December 1, 2001

Falls Brook Centre  
125 South Knowlesville Rd.  
Knowlesville, NB, E7L 1B1, Canada  
Tel: (506) 374-8143  
Fax: (506) 375-4221  
email: fbcja@web.net

Acknowledgements:

Special thanks to Heather Arnold and Jamie Simpson for their research assistance. Also, appreciation is expressed for the help received from Caroline Cox, the Northwest Coalition for Alternatives to Pesticides and the Pesticide Action Network.

Table of contents:

- 1 Introduction
  - 1.1 Purpose of study
  - 1.2 Scope of study
  - 1.3 Use of glyphosate and Btk in Maritime region
- 2 Glyphosate
  - 2.1 Background
  - 2.2 Inert ingredients
  - 2.3 Persistence and mobility in soils
  - 2.5 Effects to habitat
    - 2.5.1 Small mammals
    - 2.5.2 Large mammals
    - 2.5.3 Birds
  - 2.6 Effects to fungi, bacteria, and invertebrates
  - 2.6 Effects to riparian ecosystems
- 3 *Bacillus thuringiensis kurstaki*
  - 3.1 Background
  - 3.2 Commercial product
  - 3.3 Direct effects to specific organisms
    - 3.3.1 Effects to Lepidopteran species
    - 3.3.2 Effects to non-Lepidopteran species
    - 3.3.3 Beneficial insects
    - 3.3.4 Mammals
  - 3.4 Effects to ecosystem processes
    - 3.4.1 Persistence in soils ecosystem processed
- 4 Additional environmental factors
  - 4.1 Human health concerns
  - 4.2 Biocide production and transportation
  - 4.3 Nurseries and Seed Orchards
- 5 A discussion of relevant FSC Principles and Criteria
- 6 Recommendations
- 7 Literature Cited

Appendix 1. Methodology of studies on glyphosate impacts  
Appendix 2. Methodology of studies on Btk impacts

## 1 Introduction

In the Maritime Region concerns have been expressed that the international FSC criteria regarding the use of biocides fail to adequately address a number forest sustainability and human health issues stemming from the use of control products not prohibited under the current international criteria 6.6:

“Management systems shall promote the development and adoption of environmentally friendly non-chemical methods of pest management and strive to avoid the use of chemical pesticides. World Health Organization Type A and B and chlorinated hydrocarbon pesticides; pesticides that are persistent, toxic or whose derivatives remain biologically active and accumulate in the food chain beyond their intended use; as well as any pesticides banned by international agreement, shall be prohibited. If chemicals are used, proper equipment and training shall be provided to minimize health and environmental risks.”

Criteria 6.6 focuses on prohibiting the use of a number of older biocides based primarily on their short term acute mammalian toxicity. The criteria merely requires managers "strive to avoid" a multitude of other products known to be hazardous from both a chronic exposure and/or ecotoxicity standpoint. In addition, criticism has been expressed that the criteria is overly simplistic and misleading in its assumption that "non-chemical methods of pest management" are by nature, "environmentally friendly". It should be noted that the use of terminology such as “environmentally friendly” is specifically cited under Canada’s Pest Control Products Act regulations, which prohibit it’s use in "any representation by any means whatever for the purpose of promoting directly or indirectly the sale or other disposition of a control product".

The microbial insecticide Btk, used to reduce spruce budworm and a limited number of other moths considered to be “pests”, while it is still highly toxic to a far broader range of more than 300 non-target moth species inhabiting Maritime forests. U.S. data, based on operational Bt spraying suggests that if a species were limited in its distribution, or a unique genotype of a species was locally endemic, then the population/species would be at high risk of becoming extinct from single spray applications. over areas as limited as 4,000 ha's.

Other studies point out the co-evolutionary relationship of moths within the spruce-fir forest and their role in maintaining the successional position of Red spruce. This outcome is contradictory to Criteria 6.3, which requires that: “Ecological functions and values shall be maintained intact, enhanced, or restored...”

Currently, many industrial managers and government agencies, have chosen to convert extensive areas of the regions natural forest through the various so called "intensive" management systems derived from modern agricultural models. Current industrial capacity and accelerated provincial

government wood supply strategies remain tied to short term economic expediency, rather than clearly defined longer term ecological objectives.

The current industrial production of seedlings in nurseries, the use of herbicides used to remedy post clear cutting regeneration inadequacies, and a dependance on insecticides to "protect" insect vulnerable mono-cultured forests are all attributable more to anthropogenic objectives than natural forest succession patterns. In addition, regional inventory data indicates intensive insecticide spraying is a contributing factor to problematic forest age class structures. At the same time, studies indicate multi species temperate forests similar to those in Maritime region even show economic benefits associated with prolonged insect infestations.

The implications of operational use of herbicides, insecticides and nursery chemicals may also provide economic advantages to larger capital intensive forest operators over operations unable to afford the costs of biocide inputs per unit of production. It could also be argued biocide dependant operations would also enjoy economic advantages over forest managers who voluntarily refrain from using biocides in order to attain a higher ecological standard of management. The long term implications of continued dependance on remedial biocide products may also fail to meet current public forest management expectations expressed by surveys of public opinion in the region.

Softwood harvest levels are often based on accelerated cut effect models that have specific levels of herbicide and insecticide "crop protection" built in. Under these circumstances any long term reduction in biocide use would require proportional reductions in current and future harvest levels.

Herbicide dependence is a reliable indicator of the intensity of "competition" softwood plantations are confronting, and can accurately reflect the actual degree of conversion taking place. Plantations normally only require one application of herbicides if raspberries, ferns and other herbaceous shrubs are the primary competition. However, when hardwood stumps are sprayed before sufficient sprouting occurs to enable the adequate transfer of lethal levels of herbicide throughout the plant's root system, vigorous re-sprouting will take place. This is particularly true with species such as Red and Sugar maple, Beech and Poplar. Consequently multiple herbicide applications are required to maintain acceptable survival of softwood "crop" trees. Extensive second applications of herbicides can therefore be a reliable indicators of hardwood site conversions.

Acadian forests in U.S. Northeast and Maritime region are primarily shade tolerant temperate hardwood and softwood mixtures. Species composition throughout the Maritime region forests has shifted dramatically over the past century from shade tolerants to more insect vulnerable early successional softwood species. These changes have largely been attributed to clear cut harvesting, salvage cutting and intensive insecticide spraying. It is argued that

over the long term, insecticide spraying contributes to future forest vulnerability by enhancing the survival of balsam fir regeneration over longer lived and more insect tolerant spruces.

## 1.1 Purpose of study

The issue of biocide use in forests has prevented unanimous consensus over standards being developed under international Forest Stewardship Council (FSC) Principles and Criteria for Natural Forest Management in the Maritime Region. Economic sector representatives, supporting forest management programs which are economically dependant on the use biocides, have thus far rejected standard proposals intended to restrict current levels of biocide use. In August 1999, the Maritime Region Standards Committee (MRSC), with the exception of these representatives, endorsed Criteria 6.6.1 and 10.7.2, restricting biocide use in FSC certified forests in the region:

The use of biocides and synthetic chemical fertilizers are prohibited, except in the very rare cases where an exotic invader threatens the existence of indigenous plant or animal populations and when there is no alternative method available.

Indicators: There is no evidence of the use of synthetic chemical fertilizers or, if there is, the appropriate authorizations are on file.

In December 1999, the FSC International Board placed conditions for the endorsement of the Maritime region standards which required the MRSC endorse provisional wording for a period of twelve months. Criteria 6.6.1 and 10.7.2 was thus amended to read:

Management is explicitly committed to using no biocides in its forestry practices, and has demonstrated the steps which have been taken, and will be taken, to fulfill this commitment.

Economic chamber representatives, opposed to restricting biocide use, have the revised wording is unacceptable. In addition, Environmental chamber representatives have indicated the amended standard is unacceptable without requirements for specific timelines for the phase out of biocides.

## 1.2 Scope of study

This report has been prepared to provide background information for the MRSC regarding the development of biocide criteria for Certification Standards for Best Forestry Practices in the Maritime Forest Region. The report reviews scientific literature on adverse toxic effects of herbicides containing the active ingredient glyphosate and insecticides containing *Bacillus thuringiensis kurstaki* (Btk) toxins. This literature review of scientific papers has focused on the adverse environmental effects of B.t.k. and glyphosate. These were selected because they are currently the most widely used products within the region, and are generally considered by forest managers in the region to be the “least toxic” alternatives to other synthetic and biocide products currently registered for forestry application in Canada. Other products registered for forestry include formulations containing trichlorophon, malathion, triclopyr, carbaryl and hexazinone. In general, all have exhibited greater acute or chronic toxicity than either B.t.k. or glyphosate.

References have been organized so study methods are easily understood and compared as the studies have used different products (glyphosate only, formulated glyphosate products, or specific commercial product not reported) or application rates, and in different ecosystems, over varying time intervals since herbicide application. Details are given in Appendix 1 and 2.

In addition, other biocides used in the region, as well as broader ecological and human health aspects of biocide use are also discussed. This review should by no means be considered extensive owing to the limitations of resources available for research, various data gaps and the unavailability of proprietary information. The authors welcome comments and suggestions.

### 1.3 Forestry Use of glyphosate and Btk in New Brunswick, Nova Scotia and Prince Edward Island.

Glyphosate is the active ingredient in a number of formulated herbicide products commonly used for the purpose of vegetation control and conifer release in the Maritime region. Btk is a bacterial insecticide which is highly toxic to most species of herbivorous lepidoptera. Btk has been used to control periodic outbreaks of Hemlock looper, Spruce budworm, and Tussock moth in the region. Table 1a and 1b show the past use of glyphosate and Btk in Prince Edward Island, Nova Scotia, and New Brunswick.

Table 1a. Application of glyphosate from 1988 to 1997 (hectares)<sup>1</sup>

Year	PEI	NS	NB

Year	PEI	NS	NB
1988		10 725	22 300
1989		12 500	39 913
1990	508		32 516
1991	567	9 142	30 282
1992	413	6 440	22 360
1993	673	6 627	26 664
1994	507	7 257	24 856
1995	498	8 300	24 567
1996	202	11 716	26 450
1997		8 728	28 682

Table 1b. Application of Bt from 1988 to 1997 (hectares)<sup>1</sup>

Year	PEI	NS	NB
1988			215 910
1989			106 878
1990			226 915
1991			110 895
1992			82 271
1993			70 208
1994			17 558
1995			8 040
1996		2000	
1997		320	

\* 50,000 hectares of forest in Nova Scotia were sprayed with Btk in 1998.

Figures for insecticide use should also be viewed within the context of longer term insect population cycles and forest dynamics. During the 1970 the area of spruce budworm infestations in New Brunswick resulted in some yearly spray programs exceeding 3 million hectares.

## 2 Glyphosate

## 2.1 Glyphosate background

More than 90 glyphosate based herbicides are sold by Monsanto<sup>2</sup>. In Canada the only glyphosate formulation registered for broadcast application in forests is marketed under the tradename Vision<sup>3</sup>. It is reported by the manufacturer to be the same formulation as the more widely known Monsanto product Roundup. Most of the studies reviewed in this paper used Roundup.

Glyphosate based products are systemic, non-selective herbicides, toxic to a wide range of broadleaf herbaceous plants, grasses, sedges and woody species. In the Maritime region, trembling aspen (*Populus tremuloides* Michx.), green alder (*Alnus crispa* (Ait.) Pursh), pin cherry (*Prunus pensylvancia* L.f.), beaked hazel (*Corylus cornuta* Marsh.), willow (*Salix* spp.), blueberries (*Vaccinium* spp.), Canada blue-joint grass (*Calamagrostis canadensis* Michx. Beauv.), and raspberry (*Rubus idaeus* L. var. *strigosus* Michx. Maxim.)<sup>4,5</sup> are among a wide range of species susceptible. Glyphosate is toxic to all deciduous broadleaf species found in primary and secondary stage Maritime forests.

Glyphosate can be applied by ground or aerially, at 1.7-3.3 kg a.i./ha, prior to planting or after conifer establishment.<sup>6</sup> Once the herbicide is applied to foliage it is translocated rapidly from the foliage throughout the entire plant. The plant is killed from the inhibition of EPSP synthase, an enzyme that synthesizes aromatic amino acids which are required for growth<sup>2</sup>.

## 2.2 Inert ingredients

Commercial formulations of pesticides do not only include the active ingredient, but also ingredients listed as inert. These inert ingredients are intended to act as carriers for the active ingredient, dissolve or preserve the active ingredient, and facilitate application<sup>7</sup>. In Vision, 59% by volume is composed of inert ingredients<sup>8</sup>. Unfortunately, the formulation of inert ingredients in Vision are not listed on the product label and are considered proprietary information under current Canadian law. Since it is not known what the inert ingredients are, it is difficult to assess fully the potential long term toxicity of a commercial formulation. Canadian registration regulations require short term acute toxicity testing of formulated products which include inerts. However, longer term chronic effects studies require testing of only the active ingredient glyphosate.

This aspect of the registration process remains the source of considerable controversy. The United States Environmental Protection Agency (EPA) has identified 68 known inert ingredients as potentially toxic. Many of these ingredients are regulated in the United States under the Toxic Substances Control Act, Clean Water Act, and Clean Air Act <sup>7</sup>. The surfactant POEA, polyoxyethylene, was found to be the primary toxic ingredient in attempted suicide cases where patients ingested Roundup <sup>9</sup>. Roundup contains up to 15% POEA, and was found to be 3 times more toxic than glyphosate itself <sup>10, 11</sup>. Another surfactant of Roundup, MONO 818, has been noted as a significant cause for Roundup's toxicity to fish <sup>12, 13</sup>.

### 2.3 Persistence and mobility in soils

Glyphosate has been assumed to have low mobility and persistence in soils <sup>2</sup>. However, Piccolo et al. found that glyphosate was able to desorb from soils and was very mobile, especially in those soils that do not adsorb them well <sup>14</sup>. These were soils lacking amorphous hydrous oxides and vermiculite. Two of the soils they looked at desorbed 72% and 80% of the adsorbed glyphosate.

The reported persistence of glyphosate in soils ranges from 20 days to 4 years <sup>6, 15, 16</sup> while the half life of glyphosate in soils ranges from 20 to 133 days <sup>6, 15, 17</sup>. Some studies have also reported the persistence of AMPA which is known to persist longer than glyphosate <sup>16</sup>.

### 2.4 Effects to non-target vegetation

Since glyphosate is a broad spectrum herbicide, many species of plants are eradicated following application. On a clearcut in Nova Scotia, there was a large decrease in abundance of vegetation, especially of pteridophytes, herbaceous and woody angiosperms. There was a substantial change in relative abundance of plant taxa by the end of 6 years with a shift to conifer dominance on the sprayed plots <sup>8</sup>.

Application of herbicides can also have dramatic effects on longer term species composition and forest structure. In New Brunswick's Green River District herbicided treated plots had 270-520% more softwood stems than control plots 28 years after spraying.

Even though the objective of spraying herbicides is to remove competing vegetation, it is important to realize that species considered as weeds play important ecological roles. Moola and Mallik <sup>4</sup> stress the ecological importance of *Vaccinium* spp which is considered to be a weed species and is adversely affected by Vision <sup>5</sup>. Removal of *Vaccinium* spp. may decrease soil stability because of their dense network of roots and rhizomes <sup>18, 19</sup>. They also provide wildlife browse <sup>20, 21, 22</sup> and have ethnopharmacological value <sup>23</sup>.

## 2.5 Effects to habitat

Herbicides cause significant changes in vertical and horizontal structure of vegetation and distribution of biomass among species, abundance and quality of plant and invertebrate food resources<sup>24, 25, 26, 27, 28, 29, 30, 31, 32, 33</sup>. These changes affect wildlife species through habitat alteration. Wildlife response is species specific because of different habitat-type preferences. Certain species respond to habitat alteration by increasing their use of undamaged vegetation. Some species, however, are unable to compensate for habitat loss and decline in density. While other species respond to habitat change by increasing in density. This shift in concentration of density is due to changes in the amount of preferred habitat available to each species following herbicide application. An increase in density by certain species following treatment is not necessarily desired because this change has been artificially induced by a management practice. Increasing deer browse through herbicide application, for example, would also cause a decreased habitat availability for other species<sup>34</sup>.

The effects of glyphosate spraying on small mammals, large mammals and birds and their habitat are discussed in the following sections.

### 2.5.1 Small mammal

Red-backed voles (*Clethrionomys gapperi*) were less abundant on sprayed treatments<sup>35</sup> in Eastern Nova Scotia<sup>36</sup> and Maine<sup>37, 38</sup>. Decreases in abundance of deer mice (*Peromyscus maniculatus*)<sup>39, 35</sup>, shrews (*Sorex spp.*)<sup>40</sup>, voles (*Microtus spp.*), and chipmunks (*Eutamias spp.*)<sup>35</sup> have also been reported.

Roundup also affects enzymes found in mammals. In rats, Roundup decreased the activity of two detoxification enzymes in the liver and an intestinal enzyme. (insert ref. #14 ncap)

### 2.5.2 Large mammal habitat

Changes to habitat also negatively affects moose, elk, and mule deer. 46% of important browse for moose, 34-40% for elk and 36% for mule deer have been damaged by glyphosate application<sup>41</sup>.

Aerial application of glyphosate at 1.07 kg/ha a.i. reduced available moose browse by 5-41% and ground application at 2.7 kg/ha a.i. reduced browse by 63-92% one growing season after treatment<sup>42</sup>.

In a plantation in Southern Norway, moose browse production was reduced to 1% after spraying. Use of the plantations by moose was significantly reduced the

first and third year after spraying. *Sorbus aucuparia*, the most important winter browse in clear cuts to moose had difficulties in reestablishing after spraying <sup>43</sup> .

Another study on moose browse reported that available browse was four times more common and used 12 times more on controls than on treated plots 21 months after spraying. Pellet counts were three times greater on controls than treated areas 21 months after spraying <sup>44</sup> .

In a study on deer browse, deer rejected Douglas-fir and salal treated with Roundup at rates of 2.24-4.48 kg/ha <sup>45</sup> .

### 2.5.3 Bird habitat

Statistical relationships have been found between the abundance, species richness, and species diversity of birds and plant species composition, lifeform, vertical and horizontal stratification and patchiness <sup>46, 47, 48, 49, 50, 51, 52, 53</sup> .

In a study conducted in mixedwood clearcuts in Nova Scotia, the abundance of vegetation decreased from 149% to 81% in the first year following treatment. There was little recovery of birches and ferns over the 4 years. There was a difference in the change of bird species between treated and untreated plots. The untreated plots were colonized by black-and-white warbler, red-eyed vireo, ruby-throated hummingbird, and palm warbler which were not found on the treated plots. The treated stands also saw an increasing dominance of conifers, indicating a conversion to a conifer-dominated forest <sup>54</sup> .

In another study in Nova Scotia, lower point and decreased total species richness were observed 4 and 5 years after spraying compared to naturally regenerated sites <sup>36</sup> .

In north-central Maine, a study looked at the difference in vegetation and songbirds on clearcuts treated and untreated with Roundup. The treated clearcuts saw a reduction in the complexity of vegetation (structurally and floristically) for 3 years post-treatment. The total number of birds, common yellowthroats (*Geothlypis trichas*), Lincoln's sparrows (*Melospiza lincolnii*) and alder flycatchers (*Empidonax alnoram*) were less abundant on these treated sites.

On the Oregon coast, 1 year after treatment, the relative density of rufous hummingbird (*Selaphorus rufus*), MacGillivray's warblers (*Oporornis tolmiei*), Wilson's warblers (*Wilsonia pusilla*), rufous-sided towhee (*Pipilo erythrophthalmus*) and white-crowned sparrow (*Zonotrichia leucophrys*) decreased while the relative density of willow flycatcher (*Empidonax trallii*), orange-crowned warbler (*Vermivora celata*), dark-eyed junco (*Junco hyemalis*) and American goldfinch (*Carduelis tristis*) increased. By the second year the

species whose densities had decreased shown a relative increase and conversely for the species whose densities had increased. Compared to the controls, the relative change in density was high <sup>37</sup>.

In a conifer plantation in SE Norway, one summer after spraying, cocks and hens avoided sprayed plantations, 1-2 years after treatment <sup>55</sup>.

In the laboratory, five zebra finches died in 3-7 days following unrestricted access to seed containing 5000 µg glyphosate/g. They may have died from starvation since their food consumption was drastically reduced <sup>56</sup>.

There have been previous suggestions of leaving patches unsprayed so bird communities could be maintained, but birds in sprayed plots tended to concentrate in unsprayed islands. It was felt by numerous researchers <sup>57, 58, 59, 60, 54</sup> that these islands would be too small for birds to breed with same abundance and success.

## 2.6 Effects to fungi, bacteria, and insects

Studies on mycorrhizal fungi and nitrogen fixing bacteria, both which aid in the growth of several conifer species, have also shown negative effects of glyphosate application.

At the lowest concentration tested, 5 species of mycorrhizal fungi: *Hebeloma crustuliniforme*, *Laccaria laccata*, *Suillus tomentosus*, *Thelephora americana*, *Thelephora terrestris* isolated from lodgepole pine and white spruce forests in Alberta, significantly decreased in growth <sup>61</sup>.

At the typical application rate *Rhizobium trifolii*, a N-fixing bacteria, decreased its nodulation by 27% <sup>62</sup>. In addition, other nitrogen fixing bacteria, *Azotobacter vinelandii* and *Azotobacter chroococcum*, experienced a decrease in cell size, induced cysts and reduced respiration and nitrogen fixation. The enzyme that makes amino acids was inhibited by glyphosate resulting in reduced protein synthesis and lower growth. The growth rate of *Azotobacter vinelandii* was reduced to 82% at a recommended application rate <sup>63</sup>.

The growth of N fixing symbiont of soybean, *Bradyrhizobium japonicum*, was inhibited 10-40% by a concentration of glyphosate thought to be present in the roots after a typical application <sup>64</sup>.

At 80 ppm, glyphosate reduced spore formation of *Septoria nodorum* Berk. by 90% and growth rates of four isolates by 50-55%. Pre-treatment with Roundup reduced spore germination by 60% even when the herbicide was absent from the germination medium <sup>65</sup>.

Glyphosate has also been found to advance the colonization of lodgepole pine by the mountain pine beetle. The blue stain fungus, *Ophiostoma claverum*, is a phytopathogen symbiotic with the mountain pine beetle. Roundup-treated trees developed longer lesions and greater vertical spread of the blue stain fungus than in the control trees. This study concluded that glyphosate debilitated the tree's secondary defense response to blue stain fungus allowing for the enhanced colonization by the pine beetle <sup>66</sup>.

In a laboratory experiment with 2 isopod species, *Philoscia muscorum* and *Oniscus asellus*, they experienced a 31 and 38% decrease in longevity compared with the control animals at recommended amounts of glyphosate (5.96 ml/m<sup>2</sup>) <sup>67</sup>. In the field, invertebrates, especially herbivorous invertebrates, were less abundant on sprayed clearcuts <sup>40</sup>.

## 2.7 Effects to riparian ecosystems

In a study at the Carnation Creek watershed in British Columbia, various riparian structures and species were studied following the aerial application of Roundup. A 10 m pesticide free zone was in place for tributaries visible from the air, while there was no buffer zone in place for those tributaries not visible from the air. The application rate was at the upper-level of recommended rates.

Red alder and salmonberry were the target vegetation, but they are also known to act as key physical structures for stream edge stability and cover for the aquatic food web of coho salmon. Stream litterfall reduced to 6% of the expected litterfall in oversprayed tributaries due to defoliation of these species <sup>68</sup>. This created other environmental changes like increased sunlight on the stream surface, increased erosion, warmer stream temperatures for up to 3 years <sup>69</sup>, and increased stream nutrient inputs. Streamwater nitrate levels increased 3-fold during freshets in the year following treatment due to the release of nitrates from dead roots. The nitrate concentration did not reach toxic levels for salmonids, however. Streamwater phosphate levels also increased for 1-2 years following treatment, mainly from deciduous litter inputs <sup>70</sup>.

A 10 to 100-fold increase in algal production in the year following treatment was observed <sup>68</sup>. Since phosphorus was the limiting nutrient to algal production <sup>71</sup> the increased levels of phosphates is thought to have increased the algal production observed in conjunction with increased light.

The aquatic invertebrate abundance was 40-50% lower at treated sites after periods of frequent freshets<sup>72</sup>. *Paraleptophlebia* (mayflies) and *Gammarus* (amphipods) avoided the oversprayed areas for 24 hours following treatment<sup>73</sup>.

Temporary stress was observed for caged coho for 2 weeks following treatment while resident coho avoided the oversprayed tributary for 3 weeks. It was suggested by the authors that the surfactant rather than glyphosate was the cause for these differences as it is known to be at least 4 times more toxic than glyphosate<sup>11</sup>.

In other studies, Roundup was found to be moderately toxic to two species of Pacific salmon. The surfactant MONO818, a known inert ingredient in Roundup was highly toxic to salmonids<sup>13</sup>.

Under a range of concentrations, formulations and pH it was found that glyphosate is considerably toxic to *Lemna minor* and *Salvinia natans*, aquatic plant species that inhabit the forest ecosystem and, are part of the food-web of wildlife and fish<sup>74</sup>. Roundup also inhibited the aquatic bacterial populations of *Aeromonas hydrophila* and *Pseudomonas chlororaphis*. The researchers suggest that it is conceivable that communities of higher trophic level in the aquatic environment might also be affected and consideration must be given to the possibility of contamination of non-target environment such as streams, ponds and lakes when applying glyphosate in the field<sup>75</sup>.

Growth of two unicellular and two filamentous cyanobacteria was inhibited by glyphosate at intermediate concentrations<sup>76</sup>.

Agriculture Canada Discussion Document D91-01, on the proposed pre-harvest registration of Roundup states: A direct overspray of fish habitat could result in significant effects to fish and/or to fish habitat. Concern is enhanced by the lack of data on the fate of MON 0818 (surfactant) in aquatic systems and by the lack of an analytical method for the quantification of MON 0818 in water at concentrations lower than the NOEL for the most sensitive non-target species. The Pesticides Directorate document indicates Roundup and Vision are "identical", and concludes that in order reduce the probability of direct oversprays, and to reduce the amount of drift deposit onto fish habitat, Roundup should be applied only by ground equipment and not by air.

### 3.1 Background

*Bacillus thuringiensis* var. *kurstaki* (Btk) is a bacteria that is used as a microbial agent to control spruce budworm (*Choristoneura fumiferana*) and other herbivoreous lepidoptera in Canada. It produces a protein crystal that is toxic to Lepidoptera, the moth and butterfly family<sup>77</sup>. After larvae feed on plant matter coated with these crystals, the crystals are broken down in the gut and releases toxins that inhibit feeding<sup>78</sup>. The spores of Btk have also been found to be toxic to Lepidoptera<sup>79</sup>.

Little is known of the ecology of Bt. It is considered to be naturally occurring worldwide in soils. Martin and Travers<sup>80</sup> isolated Bt from 70.4% of 1115 soils in 30 countries and found it well represented in forest, agriculture, steppe and tundra soils. However, no indigenous Bt in untreated areas was detected in neither Nova Scotian<sup>81</sup> nor Quebec<sup>82</sup> forest soils.

Bt has been found on the leaf surfaces of temperate-climate trees suggesting that it may be an epiphyte. It also naturally occurs in areas without target insects and related insects. The toxic proteins rapidly degrade in nature and an extremely high number of spores are needed to kill larvae<sup>83</sup>. Btk has never been observed acting as a natural insecticide<sup>84, 78</sup>.

### 3.2 Commercial product

In 1993 there were 20 different formulations of Btk registered for use in Canada<sup>82</sup>, all of which are not allowed to include beta endotoxin. These formulations contain spores, Btk crystals and inert ingredients. These inert ingredients include thickening agents, culture media, chemical “stickers” and ingredients to protect microbes from ultraviolet radiation. The exact formulation is considered proprietary information and is not listed on the label. Very few studies have been done on the effects to non-target organisms with the inert ingredients themselves<sup>82</sup>. Foray 48B, a commercial formulation, has been shown to contain sodium hydroxide, sulfuric acid, phosphoric acid, methyl paraben and potassium phosphate as inerts<sup>85</sup>.

In Canada, Btk is normally applied at a rate of 10-20 billion of international units (BIU)/ha<sup>1</sup>. The insecticidal activity has been reported for more than 64 days<sup>86</sup> and over 90 days<sup>77</sup>. Any terrestrial organisms that eat leaves, litter, the uppermost layer of soil, or dead or dying caterpillars that have eaten Bt, are exposed to Bt<sup>77</sup>.

### 3.3 Direct effects to specific organisms

### 3.3.1 Effects to Lepidopterans

There are more than 300 species of lepidopterans in the Maritimes <sup>87</sup>. Two of these species are listed as endangered or vulnerable in the Maritime region. Study of operational Btk spraying of a 4,000 ha. in Oregon suggests that certain nontarget species may be ecologically at risk if it were limited in its distribution, or a unique genotype of a species was locally endemic. The population/species would be at high risk of becoming extinct from single spray applications ( insert endnote 90). Data from single applications of Btk during spruce budworm spraying suggests that uncommon species are more likely to be removed from the system than common species and that gross accounts of species richness may mask significant effects on less abundant species.(Insert endnote 91) In New Brunswick, the Maritime Ringlet Butterfly (*Coenonympha inornata nipisiquit*) is endangered <sup>88</sup> and the Monarch Butterfly (*Danaus plexippus*) is listed under the vulnerable category <sup>89</sup>

There are numerous reports of other lepidopteran species being affected by Btk spraying. The oak-caterpillar and other caterpillar numbers were reduced for 3 and 2 years after spraying to control gypsy moth <sup>90</sup>. Following spraying for spruce budworm the population of caterpillars feeding on tobacco brush collapsed. The number of species in untreated areas was about 30% higher and number of caterpillars was about 5 times higher than in Btk treated areas <sup>90</sup>. The spring moth population was reduced by 90% following spraying for gypsy moth in Washington. One rare species seems to have been eradicated and an effect on Lepidopteran populations was observed outside the treatment area <sup>92</sup>. The total weight of caterpillars decreased by 90-95%, abundance decreased by 80%, and number of species decreased by 60% following treatment, in another study <sup>85</sup>.

In a review by Krieg and Langenbuch <sup>79</sup>, they identified many other Lepidopteran species susceptible to Btk (Table 3a).

Table 3a. Susceptible lepidopteran species to spores and delta endotoxin of B.t.k. per o.s.

Genus species	Reference
<i>Aerolepia alliella</i>	Takaki 1975
<i>Adoxophyes orana</i>	Takaki 1975
<i>Agrostis segetum</i>	Laugenbruch 1977
<i>Alsophila pometaria</i>	Harper 1974
<i>Anisota senatoria</i>	Kaya 1974
<i>Anticarsaria gemmatalis</i>	Ignoffo et al. 1977
<i>Archips argyrospilus</i>	Pinnock and Milstead 1978
<i>A. rosana</i>	Vankova 1973, Ali Niazee 1974
<i>A. xylosteana</i>	Takaki 1975

Autographa nigrisigma	Takaki 1975
Caloptilia theivora	Takaki 1975
Canephora asiatica	Takaki 1975
Carposina niponensis	Takaki 1975
Chilo aurialinas	Nayak et al. 1978
Cnaphalocrosis medinalis	Srivastava and Nayak 1978
Colotois pennaria	Donaubauer and Schmutzenhofer 1973
Cryptoblabes guidiella	Wysoki et al. 1975
Cydia pomonella	Niemczyk et al. 1976
Datana integerrima	Polles 1974
Desmia funeralis	Ali Niazee and Jensen 1973
Diatraea grandiosella	Charpenter et al. 1973
Drymonia ruficornis	Pirvescu 1973
Ennomos subsignarias	Dunbar et al. 1973
Ephestia cautella	McGaughey 1979
Epiphyas porbettana	Buchanan 1977
Erinnyis ello	Abren 1974, Cruz 1977
Eriogaster lanestris	Vankova 1973
Eupoecilia ambignella	Schmid and Antonin 1977
Euproctis chrysorrhea	Vankova 1973, Gurses and Doganay 1976
E. fraterna	Takaki 1975
Eutromula pariana	Dronka et al. 1976
Euxoa messoria	Cheng 1973
Galleria mellonella	Ali et al. 1973
Harrisina brillians	Pinnock et al. 1973
Heliothis armigera	Roome 1975
Helicoverpa assulta	Takaki 1975
Heliothis virescens	Patti and Carner 1974
H. zea	Rogoff et al. 1969, Creighton et al. 1971
Herpetogramma phaeopteralis	Reinert 1974
Heterocampa guttivitta	Wallner 1971
H. manteo	Ignoffo et al. 1973
Homona magnanima	Takaki 1975
Hyphantria cunea	Morris 1972, Takaki 1975, Zivanovic and Stamenkovic 1976
Hypogymna morio	Dobrivojevic and Injac 1975

Kakivoria flavofasciata	Takaki 1975
Lacanobia oleracea	Chan Tkho 1973
Lamdira athasaria pellucidaria	Sorenson and Barbosa 1975
Lampides boeticus	Takaki 1975
Leucoma salicis	Donaubauer and Schmutzenhofer 1973
Lobesia botrana	Schmid and Antonin 1977,
Loxostege sticticalis	Iacob and Iacob 1977
Lymantria dispar	Vankova 1973, Yendol et al. 1973
L. monacha	Bejer-Peterson 1974
Malacosoma disstria	Harper 1974
M. neustria	Vankova 1973, Gurses and Doganay 1976, Takaki 1975
Mamestra brassicae	Vankova 1973, Takaki 1975
Oiketicus moyanoi	Almela Pons et al. 1972
Operophtera brumata	v.d. Geest 1971
O. fagata	Vankova 1973
Orgyia anitqua	Lipa et al. 1977
O. leucostigma	Rossmoore et al. 1970
O. pseudotsuga	Morris 1973, Stelzer et al. 1975
O. thyellina	Takaki 1975
Ostrinia nubilalis	Schuber and Stengel 1974
Paleacrita vernata	Harper 1974
Paralobesia viteana	Biever and Hostetter 1975
Paramyelois transitella	Pinnock and Milstead 1972
Parnara guttata	Takaki 1975
Pectinophora gossypiella	Graves and Watson 1970
Pericallia ricini	Kumar and Jayaraj 1978
Phthorimaea operculella	Ali 1974
Phyllonorycter ringoniella	Takaki 1975
Plathypena scabra	Ignoffo et al. 1977, Yearian et al. 1973
Plodia interpunctella	McGaughey 1978
Plutella xylostella	Takaki 1974, Creighton and McFadden 1975
Prays oleae	Tamvrias 1972
Pseudoplusia includens	Ignoffo et al. 1977, Yearian et al. 1973
Schizura concinna	Pinnock et al. 1974

Schoenobius bipunctifer	Nayak et al. 1978
Sesamia inferens	Nayak et al. 1978
Sibine apicalis	Jaramillo Celis et al. 1974
Sitotroga cerealella	Steinhaus and Bell 1953
Spodoptera exigua	Ignoffo et al. 1977, Vail et al. 1972
S. frugiperda	Creighton et al. 1972
S. litura	Takaki 1975
Syllepte derogata	Taylor 1974
Symmerista canicosta	Millars et al. 1974
Thaumetopoea pilyocampa	Videnova et al. 1972
Thumelicus lineola	McNeil et al. 1977
Thyridopteryx ephemeraeformis	Kearby et al. 1972
Tortrix viridana	Svestka 1974
Trichoplusia ni	Rogoff et al. 1969, Creighton and McFadden 1975, Jaques 1972
Yponomeuta cognatella	Hamed 1978
Y. malinella	Vankova 1973
Y. padella	Hamed 1978

---

### 3.3.2 Effects to non-lepidopteran species

Although Btk is known for its toxic specificity to Lepidopteran species, there have been numerous reports of its toxicity to other species outside of this order. Work has concentrated on organisms of socioeconomic importance like parasitic nematodes, fire ants infesting housing developments, and mites predaceous on crop pests. The effect of Bt on soil-dwelling nematodes, saprophytic mites and ants inhabiting forest floor is not well understood <sup>82</sup>.

#### 3.3.2.1 Beneficial insects

A parasite of the meal moth, *Bracon brevicornis* Wesm. encountered many negative effects following direct spraying of Dipel. There were decreases in number of eggs deposited, egg incubation, percentage hatched, larval duration, formed cocoons, percentage adult emergence and longevity. A predator of the meal moth, *Xylocoris flavipes* (Reuter), also experienced decreased in the number of larvae consumed and hatched fewer eggs following spraying <sup>93</sup>.

Following feeding of spruce budworm sprayed with Btk, the larvae of *Glypta fumiferanae* (Viereck) and *Apantelei* sp., major parasites of spruce budworm, commonly died before pupation and were filled with all stages of Bt <sup>94</sup>.

In a field study involving two parasites of *Lymantria dispar* (L.), *B. pratensis* and *C. concinnata*, parasitism decreased at half the typical application rate <sup>95</sup>.

Also, collards, aphid eating flies <sup>96</sup>, a predatory bug <sup>93</sup>, *Simulium vittatum*, an aquatic invertebrate <sup>97</sup>, ground beetles <sup>82</sup>, predaceous phytoseiid mites *Tetranychus urticae* and *Typhlodromus* sp. <sup>98</sup> experienced mortality following Btk treatment.

Table 3b lists additional species that have susceptibility to Btk spraying.

Table 3b. Susceptible non-lepidopteran species to spores and delta endotoxin of B.t.k. per o.s. <sup>79</sup>

Order	Genus species	Reference
Diptera	<i>Aedes dorsalis</i>	Goldberg 1978
	<i>A. taeniorhynchus</i>	Goldberg 1978
	<i>A. tarsalis</i>	Goldberg 1978
	<i>Eusimulium aureum</i>	Lacey et al. 1978
	<i>Hemicnetha virgatum</i>	Lacey et al. 1978
	<i>Mademyia saundersii</i>	Hamel 1977
	<i>Simulium argus</i>	Lacey et al. 1978
	<i>S. piperi</i>	Lacey et al. 1978
	<i>S. tescorum</i>	Lacey et al. 1978
	<i>S. vittatum</i>	Lacey and Mulla 1977, Lacey et al. 1978
Hymenoptera	<i>Diadegma armillata</i>	Hamed 1978
	<i>Pimpla turionellae</i>	Hamed 1978
	<i>Tetrastichus evynomellae</i>	Hamed 1978

### 3.3.2.2 Mammals

Caterpillars are a main part the shrew diet. Adult males seemed to select for caterpillars even when abundance was reduced by spraying. Fewer males were observed in the treated plots due to mortality and dispersal. There was an increase in number of juveniles, probably because of the decrease in adult males. Juveniles and adult females switched to other insects for food on the treated plots <sup>99</sup>.

### 3.3.2.3 Birds

The significance of catastrophic large scale natural or artificial reductions of insect food sources on populations of migratory birds is unknown. In New Hampshire, *Dendroica caerulescens* (Black-throated blue warblers) made fewer nesting attempts, significantly reduced the number of young fledglings per nest,

reduced nestling growth rates and survival, and reduced the number of nests attempted per pair after an aerial application of Thuricide 32LV to 30 ha. experimental plots <sup>100</sup>.

### 3.4 Effects to other ecosystem processes

#### 3.4.1 Persistence in soil

Bt spores die quickly under UV radiation so they generally disappear quickly following spraying <sup>84</sup>. However, in Eastern Canadian soils, lengthy persistence has been noted. In a Quebec study, there was only a slight decrease in concentration of Bt spores in forest soils 11 months post-spray <sup>82</sup>. There were no decline in spore levels reported 1 year after spraying with Dipel 132, a formulation containing Btk <sup>82</sup>. McBride and Coyle <sup>81</sup> found a significant residual population of Btk reported in Nova Scotian forest litter, humus and understorey foliage 1 year post-spray.

There are concerns that aerial spraying could result in the accumulation of Bt in surface horizons because of the reported persistence in soils and its low mobility downwards through the soil profile <sup>82</sup>.

#### 3.4.2 Interruption of other biological control processes

Tansy ragwort (*Senecio jacobaea* L.) occurs as a noxious weed in clearcuts and pastures in the Maritime region. The cinnabar moth (*Tyria jacobaeae* L.) has been introduced as a defoliator of tansy ragwort. Rosalind et al. <sup>101</sup> conclude that application of Btk may interfere with the biological control of this weed because it also effects the cinnabar moth.

Additional concern over the use of Bt is that it is supposed to be target specific by requiring certain mid-gut receptors, proteolytic activity, and pH for the toxicity to be expressed. However, the products of bioengineering (transgenic plants) may express the toxin directly. This would remove the requirements for specific gut conditions and potentially expand the range of non-target hosts <sup>82</sup>.

There is also strong evidence for the co-evolution of spruce budworm and red spruce, in natural forest in the Maritimes. Research indicates that the budworm is essential in maintaining spruce dominance whenever spruce and fir occur together <sup>102</sup>.

In another Nova Scotia study, hardwood cover was on average 7.8 x's less abundant in plantations sprayed with Vision than in control areas.

## 4. Additional Environmental Factors

## 4.1 Human Health

Few studies have been conducted on the chronic health effects, carcinogenicity, or mutagenicity of B.t.. However, individuals exposed to Btk have reported respiratory, eye, and skin irritation, and one corneal ulcer has occurred after direct contact with a Btk formulation. Exposed individuals have developed allergies to Btk and the “inert” ingredients. Those with compromised immune systems may be particularly susceptible to Btk <sup>103</sup> .

Viable B.t. spores are known to exist for up to one year following application. Formulations of Foray 48B have been reported to contain methyl parabin and potassium phosphate as so called “inert” ingredients. At one time both were registered by the EPA as pesticide formulation active ingredients <sup>104</sup>. While B.t. products are routinely monitored for bacterial contaminants, the risk of contamination with a disease-causing bacteria is always present <sup>105</sup>.

Adverse effects have been identified in every standard category of laboratory testing of glyphosate and its formulated products. Exposure to glyphosate has also been associated with abnormal menstration <sup>106</sup>. Research on the health of Ontario farm families has associated glyphosate use with increased miscarriages and premature births <sup>107</sup>. In addition, research in Sweden has shown an association between exposure to glyphosate and the occurrence of non-hodgkins lymphoma and leukemia<sup>108</sup>

The report, "Toxic Secrets: 'Inert' Ingredients in Pesticides, 1987 - 1997," found that more than 2,300 chemicals are now listed by the U.S. Environmental Protection Agency (EPA) as inert ingredients in pesticide formulations -- a 93% increase since 1987. "Toxic Secrets" was written by the Northwest Coalition for Alternatives to Pesticides (NCAP) and released by Californians for Pesticide Reform (CPR).

The Federal Insecticide, Fungicide and Rodenticide Act of 1972 (FIFRA), classifies pesticide ingredients into two categories, "active" and "inert." Active ingredients are designed to "destroy, prevent, repel or mitigate" a pest. Inert ingredients are all other chemicals used to make the pesticide product more potent or easier to use. There are

approximately 21,000 pesticide products on the U.S. market today. In many cases, the active ingredient listed on the label is only a small percentage of the total pesticide formulation.

According to the report, 610 chemicals used as inert ingredients have been classified as hazardous by U.S. or international agencies. For example, 20 are known or suspected carcinogens, 187 are considered hazardous air and water pollutants, and 12 have been classified as "extremely hazardous." Cristobolite, a known carcinogen, is used as an inert ingredient in over 1,500 pesticide products.

No government agency records the amount of inert ingredients used each year in the United States. EPA, however, estimates that approximately 32% of an average pesticide formulation is active ingredient and that two billion pounds of active ingredients are used annually. Based on these numbers, the report estimated that 4.1 billion pounds of inert ingredients are used throughout the U.S. each year.

At least 355 inert ingredients have been or are currently being used as active ingredients in pesticide products. When used as an active ingredient, the name of the chemical must be listed on the label and the chemical is subject to a battery of tests to determine its toxicity. However, when the same chemical is used as an inert ingredient, no such labeling and only limited studies are required.

It must be emphasized that there are still many information gaps on the long term effects to ecosystems from biocide use. All of the studies referenced have been short term. Cognitive impairment or immune system problems may manifest in different ways or to different degrees throughout the life of an organism. Reproductive difficulties are similarly hard to pinpoint. Timing is also crucial, as a single exposure can affect an embryo at a critical time of development. In this respect non-persistent biocides can be just as lethal as persistent ones. These and other factors mean that it is virtually impossible to determine with certainty what constitutes a "safe" chemical 109.

## 4.2 Biocide Production and Transportation

---

The use of biocides should not be viewed in isolation from the overall effects of various forms of environmental pollution created during manufacture and transportation. In addition, production, distribution and application of biocides remain largely dependant on the availability of non-renewable petroleum based resources. Over one billion gallons of petroleum products are used in the production of biocides in the U.S. each year<sup>110</sup>.

#### 4.3 Nurseries and Seed Orchards

#### BIOCIDES USED NURSERIES AND SEED ORCHARDS

Fungicide Product Name	Active Ingredient
Daconil	Chlorothalonil
Benelate	Benomyl
Rovral	Iprodione
Manzate	Mancozeb
Truban	Etridiazole
Captan	Captan

  

Insecticide Product Name	Active Ingredient
Safers Insecticidal Soap	Insecticidal Soap
Ambush	Permethrin
Orthene	Acephate
Sevin	Carbaryl
Pentac	Dienochlor
Metasystox	Oxydemeton-methyl
Kelthane	Dicofol
Cygon	Dimethoate
Pirimor	Pirimicarb
Diazinon	Diazinon

The list contains a number of particularly toxic products from both an occupational health and ecotoxicity perspective. Seven are chlorinated hydrocarbons prohibited under FSC criteria. Captan, diazinon, and benomyl have all been implicated in reports concerning adverse human health effects and birth defects. The fungicide chlorothalonil causes multiple cancers at low doses in laboratory test animals, and is contaminated with hexachlorobenzene, a WHO List IA chemical. In addition few of the

products listed, or their so called “inert” formulation ingredients, have ever been evaluated for hormone disruption capabilities. Data also indicates a number of these biocides persist as residues on seedlings for long periods. However, we are unaware of any published Canadian research devoted determining actual occupational exposure levels of workers handling pesticide contaminated seedlings.

The Pesticides Directorate of Agriculture Canada reviewed nursery biocide use during the late 1980's , after Nova Scotia nursery workers and tree planters reported symptoms of acute pesticide exposure. As a result, federal officials carried out corrective reviews of forest nursery practices across Canada. The review resulted in a number of nurseries significantly reducing overall pesticide dependence. Economic thresholds have been revised with positive results. As one manager explained, “we just had to learn to accept a certain level seedling mortality, sometimes in the area of 10%, as an occasional tradeoff for significant reductions in pesticide use.”

## 5 A discussion of relevant principles and criteria

### Forest Stewardship Council Principle 6

“Forest management shall conserve biological diversity and its associated values, water resources, soils, and, by so doing, maintain the ecological functions and the integrity of the forest.”

Additional criteria established to fulfill this objective, including :

Criteria 6.3:

“Ecological functions and values shall be maintained intact, enhanced or restored, including:

- a) Forest regeneration and succession;
- b) Genetic, species and ecosystem diversity;
- c) Natural cycles that affect the productivity of the forest ecosystem”

The reported adverse effects of even so called “benign” biocides containing Btk or glyphosate, particularly with regard to natural succession of red spruce and other important shade dependant species makes it difficult to justify the use and adhere to Criteria 6.3. of either in natural forests and still adhere to Criteria 6.3. and stated FSC objectives for the maintenance and restoration of natural forests.

The use of either glyphosate or Btk adversely affects ecological functions and values. Glyphosate has been shown to alter natural succession by the suppression of broad leaved species. In a Nova Scotia study, hardwood cover was on average 7.8 x's less abundant in plantations sprayed with Vision, than in control areas 5-10 years after treatment <sup>111</sup>. Thus, by favoring the development of even age conifer dominated stands, diversity and natural resistance to infestation, are jeopardized <sup>112,113</sup>.

FSC national and regional standard groups have addressed the use of biocides in certified forests in various ways. Both Estonia and Denmark's draft standards prohibit all use of pesticides and fertilizers, while Sweden only allows the use of a specific fungicide in nurseries for a limited conditional period. The U.S. Southwestern Regional draft standards states:

“6.6.a Chemical use shall be prohibited unless absolutely necessary to correct an ecological imbalance caused by human interference with natural ecosystem functioning. Such use shall take place only as part of an integrated pest or weed management system.”

These standards all exceed current FSC requirements covering biocides.

Environmental chamber requests for explanation of reasons why conditions for the endorsement Maritime standards now require consensus of a “super majority” of stakeholders have not been responded to.

Under Smartwood's Guidelines for BC for the Assessment of Natural Forest Management (July 1999), chemical pesticides are also restricted:

“6.4 Use of chemicals and biological control agents

a) Synthetic pesticides, fungicides, and herbicides are not used.

b) If less environmentally hazardous methods have proven ineffective and the land manager has applied synthetic chemicals, chemical use minimises environmental impacts and plans are in place to phase out their use over the shortest reasonable time period.”

The World Wildlife Fund, Greenpeace and other environmental chamber organizations have defined ecologically oriented IPM as follows:

“Ecologically-based IPM is a systems approach to pest management that is based on an understanding of pest ecology. It relies on resistant varieties and promoting plant

health, crop rotation, disrupting pest reproduction, and the management of the biological processes to diversify and build populations of beneficial organisms. Reduced risk pesticides, including biopesticides, are used only as a last resort and only in ways that minimize risks."<sup>114</sup>

In the Maritime region, current industrial policies directed at intensive softwood development are problematic with regard to meeting FSC criteria 6.3 Insects such as the hemlock looper and tussock moth have been shown to be more destructive in spaced spruce/fir stands in Nova Scotia. Intensively managed plantations of Black and Norway spruce, in which hardwood suppression has taken place, have also been shown to be more vulnerable to infestations of the yellowheaded sawfly<sup>115,116</sup>. These policies also run contradictory to generally accepted IPM principles which require avoidance of pests through preventive systems based strategies.

Clear cutting, followed by herbicide and pre-commercial thinning treatments, have quantifiable implications for contributing to the decline of shade tolerants across the region's forested landscape. It is important to keep in mind, the long term consequences of the removal of even remnant native populations of shade tolerants would be far more difficult to remedy, than any negative impacts on tree species composition which might result from herbicide use in catastrophic prone boreal systems, having rapid recovery dynamics.

On the positive side , a number of large industrial landowners and numerous smaller woodlot owners in the Maritime region have embraced systems based silviculture and stand management policies which conform with accepted IPM principles to reduce long term forest vulnerability.

In addition, Criterion 6.9.2 requires:

"Given the current state of knowledge, exotic control organisms are prohibited.  
Indicators:  
Exotic control organisms are not introduced."

Btk may be considered an exotic control organism because it has not been found to occur naturally in Eastern Canadian soils and does not naturally exhibit insecticidal properties. From the glossary, an exotic is "an introduced species not native or endemic to the area in question."

## 6. Recommendations

Recommendation 1:

---

Consider revisions of criteria 6.6.1 within the context of immediate and long term impacts to the ecosystem of all products currently registered for use in the Maritime region and potential contradictions with Principle 6 stated objectives to “maintain ecological functions and the integrity of the forest.”

Recommendation 2:

Define the principle characteristics and key elements of native ecosystems in order to differentiate plantations from so called “planted stands”.

Recommendation 3:

Amend principle 10.7 to read:

“Measures shall be taken to prevent and minimize outbreaks of pests, diseases, fire and invasive plant introductions. Ecologically based approaches and strategies shall form an essential part of the forest management plan, with primary reliance on prevention rather than remedial controls such as chemical or biological pesticides and fertilizers.”

7. Literature Cited:

1. Canadian Council of Forest Ministers. National Forestry Database Program. <http://nrcan.gc.ca/cfs/proj/jepb/nfdp>
2. Franz, J.E., M.K. Mao, and J.A. Sikorski. 1997. Glyphosate: A unique global herbicide. ACS Monograph 189. Washington D.C.: American Chemical Society.
3. Pitt, D.G., Thompson, D.G., Payne, N.J., and Kettela, E.G. 1993. Response of woody eastern Canadian forest weeds to fall foliar treatments of glyphosate and triclopyr herbicides. *Can. J. For. Res.* 23: 2490-2498.
4. Moola, F.M. and A.U. Mallik. 1998. Phenology of *Vaccinium* spp. in a black spruce (*Picea mariana*) plantation in northwestern Ontario: possible implications for the timing of forest herbicide treatments. *Can. J. For. Res.* 28: 1579-1585.
5. Moola, F.M., A.U. Mallik, and R.A. Lautenschlager. 1998. Effects of conifer release treatments on the growth and fruit production of *Vaccinium* spp. in northwestern Ontario.

6. Newton, M., K.M. Howard, B.R. Kelpas, R. Danhaus, C.M. Lottman, and S. Dubelman. 1984. Fate of glyphosate in an Oregon forest ecosystem. *J. Agric. Food Chem.* 32: 1144-1151.
7. Koppel, G.O. 1994. The secret hazards of pesticides: Inert ingredients. A report from the Attorney General of New York. New York State Department of Law.
8. Freedman, B., R. Morash and D. MacKinnon. 1993. Short-term changes in vegetation after the silvicultural spraying of glyphosate herbicide onto regenerating clearcuts in Nova Scotia, Canada. *Can. J. For. Res.* 23: 2300-2311.
9. Sawada, Y., Y. Nagai, U. Masashi, and I. Yamamoto. February 6, 1988. *The Lancet.* 1: 299.
10. Grossbard, E. and D. Atkinson. The herbicide glyphosate. London: Butterworths, 1985; 127-133.
11. Holtby, L.B. and S.J. Baillie. 1989. Effects of the herbicide Roundup on coho salmon fingerlings in an over-sprayed tributary of Carnation Creek, British Columbia. In *Proceedings of the Carnation Creek Herbicide Workshop, Nanaimo, BC.* P.E. Reynold, Ed.
12. Folmar, L.C., H.O. Sanders, and A.M. Julin. 1979. Toxicity of the herbicide glyphosate and several of its formulations to fish and aquatic invertebrates. *Arch. Environ. Contam. Toxicol.* 8:269-278.
13. Wan, M., R. Watts and D. Moul. 1988. Toxicity to salmonids of the herbicide Glyphosate (Roundup) and its surfactant. Department of the Environment. Environmental Protection, Pacific Region. Regional Program Report. 86-16.
14. Piccolo, A., G. Celano, M. Arienzo and A. Mirabella. 1994. Adsorption and desorption of glyphosate in some European soils. *J. Environ. Sci. Health.* 29(6): 1105-1115.
15. Feng, J.C. and D.G. Thompson. 1990. Fate of glyphosate in a Canadian forest watershed. 2. Persistence in foliage and soils. *J. Agric. Food. Chem.* 38: 1118-1125.
16. Tortensson, N.T.L., L.N. Lundgren, and J. Stenstrom. 1989. Influence of climatic and edaphic factors on persistence of glyphosate and 2,4-D in forest soils. *Ecotoxicology and Environmental Safety.* 18: 230-239.
17. Ghassemi, M., S. Quinlivan, and M. Dellarco. 1982. Environmental effects of new herbicides for vegetation control in forestry. *Environment International.* 7: 389-402.
18. Vander Kloet, S.P. and I.V. Hall. 1981. The biological flora. 2. *Vaccinium myrtilloides* Michx., velvet leaf blueberry. *Can. Field-Nat.* 95: 329-345.

19. Haeussler, S., D. Coates, and J. Mather. 1990. Autecology of common plants in British Columbia: a literature review. B.C. Minist. For. and Canada/BC Econ. Regional Dev. FRDA Rep. No. 165.
20. Martin, A.C., H.S. Zim, and A.L. Nelson. 1951. American wildlife and plants -- a guide to wildlife food habitats. Dover Publications Inc., New York.
21. Peters, S.S. 1958. Food habitats of the Newfoundland willow ptarmigan. *J. Wildl. Manage.* 22: 384-394.
22. Rogers, L.L. 1976. Effects of mast and berry crop failures on survival, growth and reproductive success of black bears. *Trans. N. Am. Wildl. Nat. Resource. Conf.* 41: 431-438.
23. Tunon, H., C. Olavsdotter and L. Bohlin. 1995. Evaluation of anti-inflammatory activity of some Swedish medicinal plants. Inhibition of prostaglandin biosynthesis and PAF-induced exocytosis. *J. Ethnopharmacol.* 48: 61-76.
24. Borrecco J.E., H.C. Black and E.F. Hooven. 1979. Response of small mammals to herbicide induced vegetation changes. *Northwest Science.* 53: 97-106.
25. Potts, G.R. 1980. The effects of modern agriculture, nest predation, and game management on the population ecology of partridges (*Perdix* and *Alectoris rufa*). *Advances in Ecological Research.* 11: 1-82.
26. Ware, G.W. 1980. Effects of pesticides on nontarget organisms. *Residue Reviews.* 76: 173-201.
27. Morrison, M.L. and E.C. Meslow. 1984. Response of avian communities to herbicide-induced vegetation changes. *Journal of Wildlife Management.* 48: 14-22.
28. Freedman, B. 1989. *Environmental Ecology.* Academic Press, San Diego, CA.
29. Freedman, B. 1991. Controversy over the use of herbicides in forestry, with particular reference to glyphosate usage. *Journal of Environmental Science and Health.* C8: 277-286.
29. Wiens, J.A. 1973. Pattern and process in grassland bird communities. *Ecol. Monogr.* 43:213-237.
30. Balda, R.P. 1975. Vegetation structure and breeding bird diversity. Pp. 59-80 in D.R. Smith, tech. Coord. Symp on management of forest and range habitats for nongame birds. U.S. For Serv. Gen. Tech. Rep. WO-1.

31. Titterington, R.W., H.S. Crawford, and B.N. Burgason. 1979. Songbird responses to commercial clear-cutting in Maine spruce-fir forests. *J. Wildl. Manage.* 43:602-609.
32. Anderson, B.W. and R.D. Ohmart. 1980. Designing and developing a predictive model and testing a revegetated riparian community for southwestern birds. Pps 434-450 in R. DeGraaf, tech. Coord. Management of western forests and grasslands for nongame birds. U.S. For. Serv. Gen. Tech. Rep. INT -86.
33. Rice, J., B.W. Anderson, and R.D. Ohmart. 1984. Comparison of the importance of different habitat attributes to avian community organization. *J. Wildl. Manage.* 48: 895-911.
34. Morrison, M.L. and E.C. Meslow. 1983. Impacts of forest herbicides on wildlife: toxicity and habitat alteration. In Transactions of the 48<sup>th</sup> North American Wildlife Conference. pp. 175-185.
35. Sullivan, T. 1990. Demographic responses of small mammal populations to a herbicide application in coastal coniferous forest: population density and resiliency. *Can. J. Zool.* 68: 874-883.
36. Milton, G.R. and J. Towers. 1990. Relationships of songbirds and small mammals to habitat features on plantation and natural regeneration sites. Canadian Institute of Forestry, Nova Scotia Department of Natural Resources.
37. D'Anieri, P., M.L. McCormack, Jr., D.M. Leslie, Jr., and S.M. Zedaker. 1986. The small mammal community in a glyphosate conifer release treatment in Maine.
38. Clough, G.C. 1987. Relations of small mammals to forest management in northern Maine. *Can. Field Nat.* 101: 40-48.
39. Ritchie, D.C., A.S. Harestad and R. Archibald. 1987. Glyphosate treatment and deer mice in clearcut and forest. *Northwest Science.* 61(3): 199-202.
40. Santillo, D.J., D.M. Leslie, and P.W. Brown. 1989. Responses of small mammals and habitat to glyphosate application on clearcuts. *J. Wildl. Manage.* 53(1):164-172.
41. Balfour, P.M. 1989. Effects of forest herbicides on some important wildlife forage species. Victoria, BC, Canada: BC Ministry of Environment.
42. Cumming, H.G. 1989. First year effects on moose browse from two silvicultural applications of glyphosate in Ontario. *Alces.* 25: 118-132.
43. Hjeljord, O. and S. Gronvold. 1988. Glyphosate application in forest-ecological aspects. *Scand. J. For. Res.* 3: 115-121.
44. Connor, J. and L. McMillan. 1990. Winter utilization by moose of glyphosate treated cutovers-an interim report. *Alces.* 26: 133-142.

45. Campbell, D.L., J. Evans, G.D. Lindsey, and W.E. Duseberry. 1981. Acceptance by black-tailed deer of foliage treated with herbicides. USDA For. Serv. Res. Pap. PNW-290.
46. MacArthur, R.H. 1964. Environmental factors affecting bird species diversity. *American Naturalist*. 42: 595-598.
47. MacArthur, R.H., H. Recher and M. Cody. 1966. On the relation between habitat selection and species diversity. *American Naturalist*. 100: 319-325.
48. MacArthur, R.H., J.W. MacArthur and J. Preer. 1962. On bird species diversity. II. Predictions of bird census from habitat measurements. *American Naturalist*. 96: 167-174.
49. Rotenberry, J.T. and J.A. Wiens. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. *Ecology*. 61: 1228-1250.
50. Rice, J., B.W. Anderson and R.D. Ohmart. 1984. Comparison of the importance of different habitat attributes to avian community organization. *Journal of Wildlife Management*. 48: 895-911.
51. Robinson, S.K. and R.T. Holmes. 1984. Effects of plant species and foliage structure on the foraging behaviour of forest birds. *Auk*. 101: 672-684.
52. Morgan, K. and B. Freedman. 1986. Breeding bird communities in a hardwood forest succession in Nova Scotia. *Canadian Field-Naturalist*. 100: 506-519.
53. Santillo, D.J., P.W. Brown, and D.M. Leslie Jr. 1989. Response of songbirds to glyphosate-induced habitat changes on clearcuts. *J. Wildl. Manage.* 53(1): 64-71.
54. MacKinnon, D.S. and B. Freedman. 1993. effects of silvicultural use of the herbicide glyphosate on breeding birds of regenerating clearcuts in Nova Scotia, Canada. *J. Appl. Ecol.* 30(3): 395-406.
55. Eggestad, M., E. Enge, O. Hjeljord and V. Sahlgaard. 1988. Glyphosate application in forest-Ecological aspects. VIII. The effect of Black Grouse (*Tetrao tetrix*) summer habitat. *Scand. J. For. Res.* 3: 129-135.
56. Evans, D.D. and M.J. Batty. 1986. Effects of high dietary concentrations of glyphosate (Roundup) on a species of bird, marsupial and rodent indigenous to Australia. *Environmental Toxicology and Chemistry*. 5: 399-401.
57. Galli, A.E., C.F. Leck, and R.T.T. Forman. 1976. Avian distribution patterns in forest islands of different sizes in central New Jersey. *Auk*. 93: 356-364.

58. Gates, J.E. and L.W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. *Ecology*. 59: 871-883.
59. Blake, J.G. and J.R. Karr. 1987. Breeding birds of isolated woodlots: area and habitat relationships. *Ecology*. 68: 1724-1734.
60. Martin, T.E. 1988. Habitat and area effects on forest bird assemblages: is nest predation an influence? *Ecology*. 69: 74-84.
61. Chakravarty, P. and S.S. Sidhu. 1987. Effect of glyphosate, hexazinone and triclopyr on in vitro growth of five species of ectomycorrhizal fungi. *Eur. J. For. Path.* 204-210.
62. Eberbach, P.L. and L.A. Douglas. 1989. Herbicide effects on the growth and nodulation potential of *Rhizobium trifolii* with *Trifolium subterraneum* L. *Plant and Soil*. 119: 15-23.
63. Santos, A. and M. Flores. 1995. Effects of glyphosate on nitrogen fixation of free-living heterotrophic bacteria. *Letters in Applied Microbiology*. 20: 349-352.
64. Moorman, T.B., J.M. Becerril, J. Lydon, and S.O. Duke. 1992. Production of hydroxybenzoic acids by *Bradyrhizobium japonicum* strains after treatment with glyphosate. *J. Agric. Food Chem.* 40: 289- 293.
65. Harris, D. and E. Grossbard. 1979. Effects of the herbicide Gramoxone W and Roundup on *Septoria nodorum*. *Transactions of the British Mycological Society*. 73: 27-33.
66. Bergvinson, D.J. and J.H. Borden. 1992. Enhanced colonization by the blue stain fungus *Ophiostoma claverum* in glyphosate-treated sapwood of lodgepole pine. *Can. J. For. Res.* 22: 206-209.
67. Ejsackers, H. 1985. Effects of glyphosate on the soil fauna. In *The Herbicide Glyphosate*. E. Grosbard and D. Atkinson (Eds.). Butterworths, London.
68. Holtby, L.B. and S.G. Baillie. 1989a. Litter-fall and detrital decomposition rates in a tributary of Carnation Creek, BC, over-sprayed with the herbicide ROUNDUP (glyphosate). In *Proceedings of the Carnation Creek Herbicide Workshop, Nanaimo, BC*. P.E. Reynold, Ed.
69. Holtby, L.B. 1989. Changes in the temperature regime of a valley-bottom tributary of Carnation Creek, BC, over-sprayed with herbicide ROUNDUP (glyphosate). In *Proceedings of the Carnation Creek Herbicide Workshop, Nanaimo, BC*. P.E. Reynold, Ed.

70. Scrivener, J.C. 1989. Changes in concentration of dissolved ions following herbicide application (glyphosate) at Carnation Creek, BC. In Proceedings of the Carnation Creek Herbicide Workshop, Nanaimo, BC. P.E. Reynold, Ed.
71. Reynolds, P.E., J.C. Scrivener, L.B. Holtby, and P.D. Kingsbury. 1989. A summary of Carnation Creek herbicide study results. In Proceedings of the Carnation Creek Herbicide Workshop, Nanaimo, BC. P.E. Reynold, Ed.
72. Scrivener, J.C. and S. Carruthers. 1989. Changes in the invertebrate populations of the main stream and back channels over-sprayed with herbicide at Carnation Creek, BC. In Proceedings of the Carnation Creek Herbicide Workshop, Nanaimo, BC. P.E. Reynold, Ed.
73. Kreuzweiser, D.P. and P.D. Kingsbury. 1989. Drift of aquatic invertebrates in a glyphosate contaminated watershed. In Proceedings of the Carnation Creek Herbicide Workshop, Nanaimo, BC. P.E. Reynold, Ed.
74. Prasad, R. 1984. Impact of glyphosate on macrophytes. *Plant Physiology*. 75: 134.
75. Chan, K. and S.C. Leung. 1986. Effects of paraquat and glyphosate on growth, respiration, and enzyme activity of aquatic bacteria. *bulletin of Environmental Contamination and Toxicology*. 36: 52-59.
76. Hutber, G.N., L. J. Rogers, and A.J. Smith. 1979. Influence of pesticides on the growth of cyanobacteria. *Z. Allg. Mikrobiol.* 19: 397-402.
77. USDA. 1995. Gypsy moth management in the United States: a cooperative approach. Environmental Impact Statement. Vol IV. Ecological Risk Assessment.
78. Cunningham, J.C., and K. van Frankenhuyzen. 1991. Microbial insecticides in forestry. *The Forestry Chronicle*. 67(5): 473-476.
79. Krieg, A. and G.A. Langenbuch. 1981. Susceptibility of Arthropod species to *Bacillus thuringiensis*. In: Burges, H.D., eds. *Microbial control of pests and plant diseases 1970-1980*. London: Academic Press. 837-896.
80. Martin, P.A. W. and R.S. Travers. 1989. Worldwide abundance and distribution of *B. thuringiensis* isolates. *Appl. Environ. Microbiol.* 55: 2436-2442.
81. McBride, R.P. and A.M. Coyle. 1981. The persistence of aerielly applied *Bacillus thuringiensis* kurstaki in Nova Scotian forest soils. Nova Scotia Department of Lands and Forests, Entomological Services, Truro. Misc. Publ.
82. Addison, J.A. 1993. Persistence and nontarget effects of *Bacillus thuringiensis* in soil: a review. *Can. J. For. Res.* 23: 2329-2342.

83. Lambert, B. and M. Peferoen. 1992. Insecticidal promise of *Bacillus thuringiensis*. *BioScience*. 42 (2): 112-122.
84. Dulmage, H.T. and K. Aizawa. 1982. Distribution of *B. thuringiensis* in nature. In *Microbial and viral pesticides*. Ed. E. Kurstak. Marcel Dekker, New York. pp. 75-208.
85. Swadener, C. 1994. *Bacillus thuringiensis* (B.T.). *Journal of Pesticide Reform*. 14 (3): 13-20.
86. Miller, J.C. and K.J. West. 1987. Efficacy of *Bacillus thuringiensis* and diflubenzuron on douglas-fir and oak for gypsy moth control in Oregon. *Journal of Arboriculture*. 13: 240-242.
87. Thomas, A.W. 1996. Light trap catches of moths within and above the canopy of a northeastern forest. *J. of the Lepidopterists Society*. 50(1): 21-45.
88. New Brunswick government. 1996. Endangered species act. New Brunswick Regulation 96-26 under the Endangered species act (O.C. 96-423).
89. Nova Scotia Department of Natural Resources. 1999. List of species occurring in Nova Scotia reviewed by COSEWIC and their national status.
90. Miller, J.C. 1990. Field assessment of the effects of a microbial pest control agent on non-target Lepidoptera. *Amer. Entomol.* (Summer): 135-139.
91. Miller, J.C. 1990. Effects of a microbial insecticide, *Bacillus thuringiensis kurstaki*, on nontarget Lepidoptera in a spruce budworm-infested forest. *J. Res. Lepid.* 29(4): 267-276.
92. Crawford, R.L. 1993. Interim one year monitoring of non-target Lepidoptera: Asian gypsy moth aerial spray area, King and Pierce counties, Washington. 30 April-13 May 1993. Interim final report in fulfillment of USDA Order No. 43-5703-C4286. Seattle, WA: University of Washington, Burke Museum.
93. Salama, H.S. et al. 1991. Parasites and predators of the meal moth *Plodia interpunctella* Hbn. as affected by *Bacillus thuringiensis* Berl. *J. Appl. Ent.* 112:244-253.
94. Thompson, C.G., J. Neisess, and H.O. Batzer. 1977. Field tests of *Bacillus thuringiensis* and aerial application strategies on western mountainous terrain. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. Portland, OR. Research Paper PNW-230. 12p.

95. Ticehurst, M., R.A. Fusco, and E.M. Blumenthal. 1982. Effects of reduced rates of Dipel 4L, Dylox 1.5 Oil, and Dimilin W-25 on *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae), Parasitism, and Defoliation. *Environmental Entomology*. 11 (5): 1058-1062.
96. Horm, D.J. 1983. Selective mortality of parasitoids and predators of *Myzus persicae* on collards treated with malathion, carbaryl, or *Bacillus thuringiensis*. *Ent. Exp. Appl.* 34: 208-211.
97. Eidt, D.C. 1985. Toxicity of *Bacillus thuringiensis* var. *kurstaki* to aquatic insects. *Can. Ent.* 117:829-837.
98. Chapman, M. and M.A. Hoy. 1991. Relative toxicity of *Bacillus thuringiensis* var. *tenebrionis* to the two-spotted spider mite and its predator *Metaseiulus occidentalis* (Nesbitt). *J. Appl. Entomol.* 111: 147- 154.
99. Bellocq, M.I. and J.F. Bendell. 1992. Effects of the insecticide *Bacillus thuringiensis* on *Sorex cinereus* (masked shrew) populations, diet, and prey selection in a jack pine plantation in northern Ontario. *Can. J. Zool.* 70: 505-510.
100. Rodenhouse and Holmes 1992
101. James, R.R., J.C. Miller and B. Lighthart. 1993. *Bacillus thuringiensis* var. *kurstaki* affects a beneficial insect, the cinnabar moth. *J. Econ. Entomol.* 86(2): 334-339.
102. Gordon, A.G. 1982. Budworm! What about the forest? In proceedings: Spruce-fir management and Spruce Budworm Society of American Foresters Region VI Technical Conference. GTR-NE-99. pp 3-29. USDA NE Forest Exp. Station, Broomall, PA. 19008.
103. Overholt, Janet 1992. Telefax to John Bell Re: Potential of Foray 48B to cause allergies. Novo Nordisk. (Feb 4)
104. 44. U.S. EPA. Prevention, Pesticides, And Toxic Substances. 1994. Status of Pesticides In Reregistration And Special Review. Washington, D.C. (June.)
105. Overholt, Janet 1992.
106. Barnard, R.J. and G. Heuser. 1995. Commonly used pesticides may help maintain facilities but can hinder athletes. *NCAA Sports Sciences Education Newsletter* (Fall):2
106. Savitz, D.A. et al. 1997. Male pesticide exposure and pregnancy outcome. *Am J Epidemiol.* 146:1025-1036.

108. Case control study of Non-Hodgkins Lymphoma and Exposure to Pesticides  
L Hardell, M Eriksson. Cancer (Jo. Am. Canc. Soc.) vol 6 (15) March 1999, 1353- 1360.

109. WWF Pollution Prevention Fact Sheet. (April 2000).

110. Aspelin, A.L. et al. 1992. Pesticide industry sales and usage: 1990-1991 USEPA  
O.P.P. Economic Analysis Div.

3 Nova Scotia Dept. of Natural Research Report No. 45: March 1993, 7-8

112. MacLean D.A. MacLean and M.G. Morgan. Long-term Growth and Yield  
Response of Young Fir to Manual and Chemical Release from Shrub Competition.  
Forest Chronicle, August 1983, 177-183

113. Schmidt W.C., et. al.. Alternatives to Chemical Insecticides in Budworm-  
Susceptible Forests, Western Wildlands, Spring 1983. 13-19.

114. Benbrook, et. al., Pest Management at the Crossroads, 1997

115. Thurston, Graham S. Control and Management of the Yellowheaded Spruce  
Sawfly in New Brunswick, Fundy Model Forest Program, pp. 1-8.

116. Lansky, M.A.. One More Bug. MacLean, Northern Forest Forum, Sept. '98, pp.5

#### Appendix 1. Methodology of studies on glyphosate impacts to ecosystem

##### Soils

Reference: Newton et al. 1984

Taxon of study: soils, water

Product and application rate: aerially applied glyphosate, 3.3 kg/ha

Study location and duration: Oregon hardwood dominated forest, 20-100 years old, 55  
days

Reported effects: half life of glyphosate is 10.4-26.6 days in foliage and litter and twice  
as long in soil; stream concentration reached 0.27 mg/L, >0.50 mg/L in sediment

Reference: Ghassemi 1982 as cited in Sullivan 1988

Taxon of study: soils

Product and application rate:

Study location and duration: laboratory

Reported effects: half-life of glyphosate in soil reported as 56 - 133 days, depending on  
soil type

Reference: Feng and Thompson 1990

Taxon of study: soils

Product and application rate: Roundup, aerially applied, 2 kg/ha

Study location and duration: coastal BC watershed  
Reported effects: 45-60 days after application, 50% or less of initial residue remained;  
360 days after application 13-18% of initial residues remain.

Reference: Tortensson et al. 1989

Taxon of study: soils

Product and application rate: Roundup, 360 g a.i./L, hand sprayed

Study location and duration: conifer plantations in northern (4 years) and southern (2 years) Sweden

Reported effects: trace amounts of glyphosate and AMPA were still found 2 and 4 years after treatment; 2 years after the application of glyphosate, AMPA accumulated to 18% of the theoretical maximum

Reference: Piccolo et al. 1994

Taxon of study: soil

Product and application rate: 99.8% glyphosate

Study location and duration: laboratory, 4 different types of European soils

Reported effects: 2 of the soil types desorbed 72% and 80% of adsorbed glyphosate

Small mammals

Reference: Milton and Towers 1990 as cited in Lautenschlager 1993

Taxon of study: Red-backed voles

Product and application rate: glyphosate

Study location and duration: Eastern Nova Scotia, 3-5 years post treatment

Reported effects: Red-backed voles were less common on herbicide-treated plantations

Reference: Clough 1987 as cited in Lautenschlager 1993

Taxon of study: Red-backed voles

Product and application rate: glyphosate

Study location and duration: North-central Maine, 1 growing season post treatment

Reported effects: lower density of red-backed voles compared to a nearby, slightly older, untreated plantation

Reference: D'Anieri et al. 1986

Taxon of study: redback vole, masked shrew, deer mouse, pygmy shrew

Product and application rate: glyphosate, product nor application rate not mentioned

Study location and duration: 4 year old spruce and fir plantation in Maine, 4 trapping periods over 4 months

Reported effects: abundance of redback voles (*Clethrionomys gapperi*) was significantly less in the glyphosate-treated sites

Reference: Ritchie et al. 1987

Taxon of study: deer mice (*Peromyscus maniculatus*)

Product and application rate: Roundup, 1.2 kg a.i. kg/ha aerially sprayed

Study location and duration: clear cuts on Vancouver Island,

Reported effects: deer mice less abundant in treated clearcut compared to untreated, "Glyphosate altered vegetation and reduced density of deer mice in young seral stages. Habitat changes induced by glyphosate likely modified abundance and quality of food and cover for small mammals."

Reference: Sullivan 1990

Taxon of study: deer mice, chipmunks, Oregon voles, red-backed voles

Product and application rate:

Study location and duration:

Reported effects: Deer mice were found to have lower resiliency after habitat alteration; chipmunk population in sprayed areas declined when compared with non-sprayed areas two years following treatment; female Oregon voles in non-sprayed areas lived significantly longer (12 weeks) than those in sprayed areas; incidental captures of red-backed voles were less common on sprayed vs. non-sprayed areas.

Reference: Santillo et al. 1989

Taxon of study: insect eating shrews, plant eating voles

Product and application rate:

Study location and duration: Maine clearcuts

Reported effects: abundance of insect eating shrews declined for 3 years post-treatment, plant eating voles declined for two; fewer small mammals were captured on glyphosate-treated clearcuts 1-3 years post-treatment compared to untreated clearcuts; differences in small mammal abundance paralleled herbicide-induced reductions in invertebrates and plant food and cover.

Reference: Haugen, and Lunde 1981 as cited in Sullivan 1988

Taxon of study: small rodents

Product and application rate: aerially sprayed glyphosate

Study location and duration: 7 year old spruce plantation in Norway

Reported effects: no grass and 30% of herbs remained after spraying "suggesting that treatment might deprive field mice of much of their food and (in snow-free periods) cover"; spraying also increased the sugar content of spruce bark (up to 41 %) and needles which the authors suggested "might make the trees more palatable to rodents"

Large mammals

Reference: Campbell et al. 1981

Taxon of study: deer

Product and application rate: Roundup

Study location and duration: Washington laboratory, 4 months

Reported effects: deer rejected Douglas-fir and salal as browse (typical browse plants for deer) treated with Roundup at rates of 2.24-4.48 kg/ha

Reference: Connor and McMillan 1990 as cited in Lautenschlager 1993

Taxon of study: moose

Product and application rate: glyphosate

Study location and duration:

Reported effects: "Available browse was four times more common and used 12 times more on controls than on treated plots 21 months after spraying. Pellet counts were three times greater on controls than treated areas 21 months after spraying. More moose tracks were observed on control than on treated plots 31 months after spraying."

Reference: Cumming 1989 as cited in Lautenschlager 1993

Taxon of study: moose

Product and application rate: glyphosate

Study location and duration:

Reported effects: "Application of glyphosate at 1.07 kg/ha (aerial) and 2.7 kg/ha (ground) reduced available moose browse by 5-41% and 63-92% respectively, one growing season after treatment."

Reference: Hjeljord and Gronvold 1988

Taxon of study: moose

Product and application rate: glyphosate, product and application rate not indicated

Study location and duration: plantations in Southern Norway

Reported effects: moose browse production was reduced to 1% after spraying; use of the plantations was significantly reduced the first and third year after spraying; *Sorbus aucuparia*, the most important winter browse in clearcuts to moose had difficulties in reestablishing after spraying

Birds

Reference: Eggestad et al. 1988

Taxon of study: Black Grouse (*Tetrao tetrix*)

Product and application rate: aerially sprayed with glyphosate, product name and amount not reported

Study location and duration: conifer plantation in SE Norway, one summer

Reported effects: cocks and hens avoided sprayed plantations, 1-2 years after treatment

Reference: Milton and Towers 1990 as cited in Lautenschlager 1993

Taxon of study: songbirds

Product and application rate: glyphosate

Study location and duration: Nova Scotia

Reported effects: lower point and decreased total species richness was observed 4 and 5 years after spraying compared to naturally regenerated sites

Reference: Evans and Batty 1986 as cited in Sullivan 1988

Taxon of study: zebra finches (*Phoephila guttata*)

Product and application rate: glyphosate

Study location and duration: laboratory

Reported effects: Five zebra finches died in 3-7 days following unrestricted access to seed containing 5000 µg glyphosate/g. They may have died from starvation since their food consumption was drastically reduced.

Reference: Morrison and Meslow 1984

Taxon of study: birds

Product and application rate: glyphosate, 37L/acre

Study location and duration: Oregon coast clearcuts, 2 years

Reported effects: 1 year after treatment, the relative density of rufous hummingbird (*Selaphorus rufus*), MacGillivray's warblers (*Oporornis tolmiei*), Wilson's warblers (*Wilsonia pusilla*), rufous-sided towhee (*Pipilo erythrophthalmus*) and white-crowned sparrow (*Zonotrichia leucophrys*) decreased while the relative density of willow flycatcher (*Empidonax trallii*), orange-crowned warbler (*Vermivora celata*), dark-eyed junco (*Junco hyemalis*) and American goldfinch (*Carduelis tristis*) increased. By the second year the species whose densities had decreased shown a relative increase and conversely for the species whose densities had increased. Compared to the controls, the relative change in density was high.

Reference: Santillo et al. 1989b

Taxon of study: birds

Product and application rate: Roundup

Study location and duration: clearcuts in north-central Maine

Reported effects: This study in north-central Maine looked at the difference in vegetation and songbirds on clearcuts treated and untreated with Roundup. Songbird densities were correlated with habitat complexity, especially hardwood regeneration, foliage height diversity, and vegetation height. The treated clearcuts saw a reduction in the complexity of vegetation (structurally and floristically) for 3 years post-treatment. The total number of birds, common yellowthroats (*Geothlypis trichas*), Lincoln's sparrows (*Melospiza lincolni*) and alder flycatchers (*Empidonax alnorum*) were less abundant on treated sites. Breeding birds are effected by herbicides as they alter vegetative structure (Wiens 1973, Balda 1975, Titterton et al. 1979), foliage diversity (Rotenberry et al. 1979, Roth 1979, Anderson and Ohmart 1980), and vegetative species composition (Balda 1969, Rice et al. 1984)

Fungi, bacteria, and invertebrates

Reference: Chakravarty and Sidhu 1987

Taxon of study: 5 species of mycorrhizal fungi: *Hebeloma crustuliniforme*, *Laccaria laccata*, *Suillus tomentosus*, *Thelephora americana*, *Thelephora terrestris* isolated from lodgepole pine and white spruce forests in Alberta

Product and application rate: Roundup, 0-1000 ppm

Study location and duration: laboratory

Reported effects: significant differences of in vitro growth at 50 ppm of all 5 species studied

-“herbicides known to inhibit in vitro growth of mycorrhizal fungi”

-recommended rate of Roundup is 1-4 a.i./ha---4-18 ppm

Reference: Santos and Flores 1995

Taxon of study: free-living, heterotrophic, nitrogen-fixing bacteria; *Azotobacter vinelandii* and *Azotobacter chroococcum*

Product and application rate: Roundup, 0-28 kg/ha

Study location and duration: laboratory

Reported effects: growth rate at 82% for *Azotobacter vinelandii* at 4 kg/ha; decreased cell size in presence of glyphosate of both *Azotobacter vinelandii* and *Azotobacter chroococcum*; cysts induced in presence of glyphosate; cell structure of vegetative and cyst cells affected by glyphosate (enzyme that makes amino acids was inhibited resulting in reduced protein synthesis and lower growth); respiration and N-fixation reduced

Reference: Eberbach and Douglas 1989

Taxon of study: *Rhizobium trifolii*, N-fixing bacteria

Product and application rate: glyphosate

Study location and duration: laboratory

Reported effects: At concentration of 2 mg/l (typical application rate) nodulation decreased by 27%. At concentration of 10 mg/l nodulation decreased by 74%. While nodulation and nitrogenase activities are reduced by glyphosate, legume growth may not suffer as plants increase their assimilation of soil inorganic nitrogen. Hence it is likely that the *Rhizobium* is more damaged by the herbicide than its symbiotic partner - the legume.

Reference: Harris and Grossbard 1979 as cited in Sullivan 1988

Taxon of study: *Septoria nodorum* Berk.

Product and application rate: Roundup

Study location and duration: laboratory

Reported effects: at 80ppm, glyphosate reduced spore formation of *Septoria nodorum* Berk. by 90% and growth rates of four isolates by 50-55%; pre-treatment with Roundup reduced spore germination by 60% even when the herbicide was absent from the germination medium

Reference: Moorman et al. 1992

Taxon of study: N fixing symbiont of soybean, *Bradyrhizobium japonicum*

Product and application rate: glyphosate

Study location and duration: laboratory

Reported effects: *Bradyrhizobium japonicum*'s growth was inhibited 10-40% by a concentration of glyphosate thought to be present in the roots after a typical application. It was also noted that nodules would be a sink for glyphosate since its translocation seems to be similar to sucrose.

Reference: Bergvinson and Borden 1992

Taxon of study: blue stain fungus, *Ophiostoma claverum*

Product and application rate: Roundup, 360 mg active ingredient/ mL

Study location and duration: laboratory

Reported effects: Study of the impacts of blue stain fungus and subsequent colonization by mountain pine beetle in lodgepole pine whose sapwood was injected through root collar with Roundup (360 mg active ingredient /ml). Roundup-treated trees developed longer lesions than control trees. Blue stain fungus (phytopathogen symbiotic with mtn. pine beetle) had greater vertical spread on treated trees than control trees. Other

studies have found that colonization by mountain pine beetle is more advanced in Glyphosate treated trees. Paper concludes that enhanced colonization of pine beetle is enabled by glyphosate's debilitation of the tree's secondary defense response to blue stain fungus.

Reference: Eijsackers 1985

Taxon of study: isopods, *Philoscia muscorum* and *Oniscus asellus*

Product and application rate: glyphosate

Study location and duration: laboratory

Reported effects: 31 and 38% decrease in *Philoscia muscorum* and *Oniscus asellus* longevity compared with the control animals with application of recommended amounts of glyphosate (5.96 ml/m<sup>2</sup>)

Aquatic ecosystems

Reference: Folmar et al. 1979

Taxon of study: fish and aquatic invertebrates

Product and application rate: Roundup

Study location and duration: laboratory

Reported effects: Study of glyphosate's toxicity when used to control undesirable vegetation in and along irrigation and reservoir systems of W. USA. Acute toxicity of Roundup ranges from 2.3 mg/l (to minnows after 24 hrs) to 43 mg/l (to scuds after 96 hrs). Roundup's surfactant MONO 818 is probably responsible for most of Roundup's toxicity. Egg stage is least sensitive to Roundup, however LC increases through fry to fingerling to adult.

Reference: Holtby and Baillie 1987

Taxon of study: coho salmon fingerlings

Product and application rate: Roundup, 1.88 kg/ha, aerially applied

Study location and duration: Carnation Creek watershed (coastal BC)

Reported effects: coho fingerlings showed signs of stress and were less active in sprayed channel for up to 3 weeks after spraying

Reference: Wan et al. 1988 as cited in Sullivan 1988

Taxon of study: Pacific salmon

Product and application rate: Roundup

Study location and duration:

Reported effects: Roundup was moderately toxic to two species of Pacific salmon; the surfactant MONO818 was highly toxic to salmonids.

Reference: Hutber et al. 1979 as cited in Sullivan 1988

Taxon of study: cyanobacteria

Product and application rate: glyphosate

Study location and duration:

Reported effects: Growth of two unicellular and two filamentous cyanobacteria was inhibited by glyphosate at intermediate concentrations

Reference: Prasad 1984 as cited in Sullivan 1988

Taxon of study: two aquatic plants (Lemna minor and Salvinia natans)

Product and application rate: glyphosate

Study location and duration: laboratory

Reported effects: both Lemna minor and Salvinia natans species inhabit the forest ecosystem and, are part of the food-web of wildlife and fish; under a range of concentrations, formulation and pH it was found that, glyphosate is considerably toxic to these aquatic plants (ED50: 5ppm for L. Minor)

Reference: Chan and Leung 1986 as cited in Sullivan 1988

Taxon of study: aquatic bacteria (Aeromonas hydrophila and Pseudomonas chlororaphis)

Product and application rate: Roundup, 20 ppm

Study location and duration: experimental pools in Hong Kong, 30 days

Reported effects: Roundup inhibited the bacterial populations and it is conceivable that communities of higher trophic level in the aquatic environment might also be affected; consideration must be given to the possibility of contamination of non-target environment such as streams, ponds and lakes when applying glyphosate in the field.

## Appendix 2. Methodology of studies on Btk impacts

Reference: Salama et al. 1991

Species: *Bracon brevicornis* Wesm., parasite of *Plodia interpunctella* Hbn., meal moth and *Xylocoris flavipes* (Reuter), predator of meal moth

Dose: 16 - 500 g/g Dipel

Method: laboratory

Effect: *Bracon brevicornis* Wesm.: decrease in number of eggs deposited, egg incubation, percentage hatched, larval duration, formed cocoons, percentage adult emergence and longevity; *Xylocoris flavipes* (Reuter): decrease in number of larvae consumed and eggs hatched

Reference: Thompson et al. 1977

Species: *Glypta fumiferanae* (Viereck) and *Apantelei* sp., major parasites of spruce budworm

Dose: 7.264 BIU/acre of Dipel , 8 BIU/hectare of Thuricide

Method: aerially applied to Douglas-fir and grand fir stands

Effect: parasite larvae commonly died before pupation and were filled with all stages of B.t.

Reference: Ticehurst et al. 1982

Species: *B. pratensis* and *C. concinnata*

Dose: 19.8 BIU (AI)/ha, Dipel 4L

Method: Aerially sprayed at half the commonly used rate

Effect: Reduced parasitism of *Lymantria dispar* (L.)

Reference: Eidt 1985

Species: *Simulium vittatum* (an aquatic invertebrate)

Dose: 430IU/mL

Method:

Effect: Heavy mortality

Reference: Buckner et al. 1974 referenced in Addison 1993

Species: Ground beetles

Dose: Dipel WP

Method: Aerially sprayed in spruce-fir and aspen-spruce forest

Effect: decline in number of ground beetles

Reference: Chapman and Hoy 1991 referenced in Addison 1993

Species: predaceous phytoseiid mites (Acari: Gamasida) *Tetranychus urticae* and *Typhlodromus* sp.

Dose: Dipel 2x

Method: Sprayed leaf discs for 5 seconds (48 hours)

Effect: moderately toxic to mites

Reference: Bellocq and Bendell 1992

Species: *Sorex cinereus* (masked shrew)

Dose: Dipel 8L at 30 BIU, 1.8 L/ha

Method: Aerially applied  
Effect: Fewer adult males and more juveniles in treated areas

Reference: Rodenhouse and Holmes 1992  
Species: *Dendroica caerulescens* (Black-throated blue warblers)  
Dose: Thuricide 32LV with Rhoplex sticker, 3.5L/ha  
Method: Aerially applied, 4 year study  
Effect: Fewer nesting attempts, significant reductions in number of young fledglings per nest, nestling growth rates and survival, number of nests attempted per pair

---