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Food Production and Inspection Branch — Direction générale, Production et inspection des aliments

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Canada

D93-02

Discussion Document

Special Review of Carbofuran Insecticide: Effects on Avian Fauna and Value to Agriculture

The special review of the registration status of carbofuran insecticide was prompted by concerns expressed by the Canadian Wildlife Service of Environment Canada regarding the negative impacts of carbofuran-containing products on wild bird populations. Following discussions with the Canadian Wildlife Service and the manufacturer of carbofuran, Agriculture Canada decided that the hazards and risks of carbofuran to wild bird populations and the value of carbofuran to Canadian agriculture would be reviewed in order to make a best-balanced decision regarding the future of carbofuran use in Canada. The purpose of this Discussion Document is to provide a summary of the data reviewed and to present regulatory options regarding the future registration status of carbofuran and each of its currently registered uses. This document is presented as a basis for discussion as part of the consultative regulatory management process used by Agriculture Canada and its advisory agencies in making significant or complex registration decisions on pesticides.

(aussi publié en français)

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Table of Contents

1.0 Introduction

In June 1990, Agriculture Canada issued Announcement Document A90-02 concerning the special review of carbofuran insecticide, trade name Furadan[1]. The purpose of the announcement was to notify registrants, pesticide regulatory officials, and other interested and affected parties that products containing carbofuran were subject to a special review under the authority of Section 19 of the *Pest Control Products Regulations*.

The Special Review of carbofuran was prompted by concerns expressed by the Canadian Wildlife Service (CWS) of Environment Canada regarding the negative effects of carbofuran-containing products on wild bird populations. Following discussions with the manufacturer (FMC Corporation, Philadelphia, PA), the Canadian distributor (Chemagro Ltd., Etobicoke, Ontario) and CWS, Agriculture Canada decided that the hazards and risks of carbofuran to avian fauna and the value of carbofuran use to Canadian agriculture would be reviewed in an attempt to reach a best-balanced decision regarding the future of carbofuran use in Canada. The scope of the Special Review was to consider only the effects of carbofuran on avian fauna and the value of carbofuran use to agriculture.

Since the release of Announcement A90-02, Agriculture Canada and the CWS have received and reviewed information submitted by FMC Corp. and Chemagro Ltd. on both the hazards and risks of carbofuran to avian fauna and the value of carbofuran use to Canadian agriculture. The CWS has prepared a risk assessment on the impact of carbofuran use to terrestrial wildlife, primarily bird species. The registrants, FMC Corp. and Chemagro Ltd., have provided an assessment of the value of carbofuran use to agriculture.

The purpose of this document is to provide summaries of the risk and value assessments, and to present regulatory options, and their associated impacts, regarding the future registration status of carbofuran and each of its currently registered uses. Although references are made in this document to alternatives to carbofuran, the document does not attempt to present a complete assessment of the relative risks and benefits of alternatives to carbofuran. Such an assessment is beyond the scope of the Special Review.

This document is presented as a basis for discussion as part of the consultative regulatory management process used by Agriculture Canada in making significant and complex registration decisions on pesticides. Interested and affected parties are invited to comment on the subject matter presented in this document.

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[1] *Furadan is a registered trademark of FMC Corporation for products containing the active ingredient carbofuran. Furadan products are sold in Canada by Chemagro Ltd.*

Please send your comments, in writing (2 copies), within 90 days of the issue date of this document to:

Carbofuran Special Review
Plant Industry Directorate
Agriculture Canada
2200 Walkley Road
Ottawa, Ontario
K1A 0C5

Comments received within 90 days of the issue date of this document will be considered prior to making a decision on the future registration status of carbofuran and each of its currently registered uses.

Inquiries regarding the Discussion Document can be made to:

Information Service
Plant Industry Directorate
Phone: 1-800-267-6315

2.0 Background

Carbofuran is a broad-spectrum, systemic, contact and stomach insecticide belonging to the carbamate class of cholinesterase-inhibiting chemicals.

2.1 Chemical Name and Properties of the Technical

2.1.1 Chemical Name

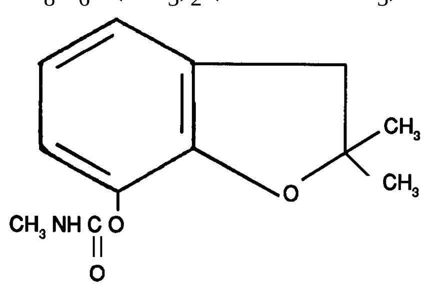
Common Name:	carbofuran
Chemical Name:	2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate
Trade Name:	Furadan
CAS Registry No.:	1563-66-2
Canadian Patent No.:	824686

2.1.2 Physical and Chemical Properties of Technical

Empirical Formula: $C_{12}H_{15}NO_3$

Molecular Formula: $C_8H_6O(CH_3)_2$ $(OOCNHCH_3)$

Structural Formula:



Molecular Weight:	221.25
Physical Form:	crystalline solid
Melting Point:	150-153ºC
Vapor Pressure:	8.7×10^{-4} mm Hg at 25ºC
Octanol/Water Partition Coefficient (K_{ow}):	17 for 1 ppm at 20º 26 for 10 ppm at 20ºC
Solubility:	water - 0.07% at 25ºC acetone - 15.0% at 25ºC xylene - 1.0% at 25ºC
Specific Gravity:	1.18
Stability - Hydrolysis (half-life at 25ºC):	>20,000 h at pH 3.1 >7,000 h at pH 6.2 13.3-16.4 h at pH 9.1 2.2 h at pH 9.9

2.2 Registered Products and Uses

Carbofuran is manufactured by FMC Corporation of Philadelphia, PA and is distributed in Canada by Chemagro Ltd. of Etobicoke, Ontario under the trade name Furadan. Furadan was first registered in Canada in 1969. There are currently seven Furadan products registered in Canada representing two formulation types (i.e., granular and flowable). The registered products are presented in Table 1.

Table 1

Product Name	Registration Number	Registrant	Classification
Furadan 480F	10363	FMC Corp.	Restricted
Furadan 5G	10666	FMC Corp.	Commercial
Furadan 5G	10826	Chemagro Ltd.	Commercial
Furadan 10G	10827	Chemagro Ltd.	Agricultural
Furadan 480F	10828	Chemagro Ltd.	Restricted
Furadan CR-10	17940	Chemagro Ltd.	Commercial
Furadan CR-10	18175	FMC Corp.	Commercial

The granular formulations consist of sand-based (10G) or corn cob-based (5G, CR-10) granules containing 5% (5G) or 10% (10G, CR-10) carbofuran by weight. The granular formulations are registered for use on certain field and row crops. A summary of these uses is presented in Table 2 (a more detailed summary of uses, and limitations on uses, is presented in Appendix 1). The granular formulations are applied to the soil at the time of seeding.

Table 2: Summary of Registered Uses of Granular Carbofuran

Crop	Pest	Rate (kg active/ha)	Maximum Number of Applications
Potato	Wireworm[A]	3.25-5.5	1
	Colorado Potato Beetle Potato Flea Beetle Potato Leafhopper	3.25	1
Turnip, Rutabaga	Root Maggot	2.5-3.6	1
Onions (dry)	Onion Maggot	1.75	1
Corn Field, Sweet, Silage	Northern and Western Corn Rootworm	1.10	1
Sugar beets	Root Maggot	0.85	1
Canola, Mustard	Flea beetles	0.225-0.28	1
Carrot[A]	Carrot Rust Fly (first generation only), six-spotted leafhopper	2.25	1

A Carbofuran is registered, but not currently marketed for this use.

The flowable formulation (480F) is a liquid which forms a suspension when diluted with water. The product can be applied by ground or aerial equipment. Timing of application varies depending on the insect and crop, but is primarily after germination of the crop. The flowable formulation is registered for use on most of the same crops as the granular formulation, in addition to other crops and use areas. A summary of these uses is presented in Table 3 (a more detailed summary of uses, and limitations on uses, is presented in Appendix 1).

Table 3: Summary of Registered Uses of Flowable Carbofuran.

Crop	Pest	Rate (kg active/ha)	Maximum Number of Applications
Turnip, Rutabaga	Root Maggot Flea Beetle	2.52	3(East) 3(Prairies) 4(B.C.)
Raspberries (B.C.)	Bud or Root Weevil	0.528-1.2	2
Strawberries	Root Weevil Spittlebug	0.528-1.2	-[A]
	Strawberry Clipper Weevil Tarnished Plant Bug	0.528	1
Sugar Beets	Sugar Beet Root Maggot	1.12	1
Potatoes	Aphids	0.528-0.816	-[A]
	Colorado Potato Beetle Potato Flea Beetle	0.264-0.528	
	Potato Leafhopper Tarnished Plant Bug	0.528	
Green Peppers	European Corn Borer	0.528	6
Corn Sweet, Field, Silage	European Corn Borer	0.528	4
	Western and Northern Corn Rootworm	0.24	
Sweet, Field	Grasshopper	0.132	2
Alfalfa	Alfalfa Weevil Alfalfa Blotch Leafminer	0.264	-[A]
	Grasshopper	0.132	2
Canola, Mustard	Flea Beetle	0.072-0.132	1[B]
	Red Turnip Beetle Grasshopper	0.132	1
Wheat	Orange Wheat Blossom Midge Grasshopper	0.132	2
Sunflower	Sunflower Beetle Grasshopper	0.132	2
Barley Flax, Headlands, Oats, Pastures, Roadsides, Sweet Clover	Grasshopper	0.132	2 1 2 2 2 2 2

[A] Maximum number of applications not specified.
[B] Not more than 0.132 kg/ha may be applied per season.

2.3 International Status

Carbofuran products are used worldwide for control of insects on a wide variety of agricultural crops including bananas, coffee beans, grapes, potatoes, corn, rice, sugarcane, and wheat.

In 1985 the U.S. Environmental Protection Agency (EPA) announced a special review of all registered uses of granular carbofuran in the United States because of concerns regarding the negative impact on bird species. The special review resulted in a negotiated settlement between the EPA and the registrant, FMC Corp., to phase out all but five minor uses of granular carbofuran in the United States. As stated by the EPA, “none of [the] risk reduction measures [evaluated by the EPA] were adequate to reduce the risk to birds, given the high toxicity of carbofuran granules.” The registrations of granular carbofuran retained by the EPA included uses on cucurbits, cranberries and pine seedlings.

The formal special review of carbofuran conducted by the EPA involved only the granular formulations. The flowable formulation, which is currently registered in the U.S. for many of the same uses in Canada, was not involved in the formal special review conducted by the EPA.

3.0 The Hazards and Risks of Carbofuran to Terrestrial Wildlife

The Canadian Wildlife Service (CWS) of Environment Canada has reviewed the available data on the hazards and risks of carbofuran to birds and other terrestrial vertebrate wildlife. The following is a summary of the key points of the risk assessment prepared by the CWS. The complete Risk Assessment is available upon request from the CWS at the following address:

Dr. P. Mineau
Canadian Wildlife Service
Toxic Chemicals Division
100 Gamelin Blvd., Rm. 103
Building #9
National Wildlife Research Centre
Hull, Quebec
K1A 0H3

This summary as well as the full risk assessment document published by the Canadian Wildlife Service reviews only the risks that carbofuran use poses directly to vertebrate wildlife through acute toxicity. This is the area of greatest concern associated with this insecticide. Any potential concerns relating to sublethal effects of the pesticide or effects on vertebrate wildlife mediated through removal of invertebrate or vertebrate food supply are not covered here.

Carbofuran is a carbamate insecticide that inhibits cholinesterase enzymes and disrupts nervous transmission in vertebrate and invertebrate species alike. Carbofuran is classified as extremely hazardous to humans based on acute oral rat LD_{50} values in the

8–14 mg/kg range.[2] For the flowable formulation, this means that just a few drops are potentially lethal. This is the approximate LD_{50} for the *least* sensitive bird species. The toxicity of carbofuran to a number of bird species is given in Table 4.

Table 4: Acute oral toxicity of technical-grade carbofuran to birds, in order from the most sensitive to the least sensitive species tested

Species	Sex	Age	LD_{50} (mg/kg)	95% confidence interval
Fulvous Whistling-Duck (Dendrocygna bicolor)	F	3-6 mo.	0.238	0.200-0.283
Mallard (Anas platyrhynchos)	U U U F M/F M* F*	33-39 h 6-8 d 27-33 d 3-4 mo. 6 mo. 12 mo. 12 mo.	0.370 0.628 0.510 0.397 0.415 0.480 0.510	0.283-0.484 0.530-0.744 0.410-0.635 0.315-0.500 0.333-0.516 0.381-0.604 0.410-0.635
Red-winged Blackbird (Agelaius phoeniceus)	U	adult	0.422	
Red-billed Quelea (Quelea quelea)	U	adult	0.422-0.562	
Americal Kestrel (Falco sparverius)	M/F	1-4 yr.	0.6	0.5-1.0
House Finch (Carpodacus mexicanus)	U	adult	0.750	
House Sparrow (Passer domesticus)	U	adult	1.33	
Rock Dove (Columba livia)	U	adult	1.33	
Brown-headed Cowbird (Molothrus ater)	U	adult	1.33	
Common Grackle (Quiscalus quiscula)	U	adult	1.33-3.16	
Japanese Quail (Cotumix coturnix)	M F	14 d 14 d	1.9 1.7	1.7-2.1 1.3-1.9
Eastern Screech-Owl (Otus asio)	M/F	2-5 yr.	1.9	1.4-2.7
Ring-necked Pheasant (Phasianus colchicus)	F	3 mo.	4.15	2.38-7.22
Northern Bobwhite (Colinus virginianus)	F M/F M/F	3 mo. 16-20 wk. 1-2 yr.	5.04 12 8.0	3.64-6.99 7.0-19 6.0-10
European Starling (Sturnus vulgaris)	U	adult	5.62	

M = male U = sex unknown F = female * = in breeding condition

It is not unusual for birds to be more susceptible than mammals to cholinesterase-inhibiting insecticides. However, the LD_{50} values given in Table 4, which are below 1 mg/kg for the two species of waterfowl tested, half of the songbirds, and one of the two birds of prey, mean that carbofuran has one of the highest recorded toxicities to birds of any insecticide registered for use in Canada.

[2] *This is the acute dose calculated to kill half of the test population to which it is given. It is expressed in mg of technical carbofuran per kg of body weight.*

Carbofuran is available both as granular and liquid (flowable) formulations. Because of different exposure potentials of the granular versus liquid formulations of carbofuran, their hazards to birds and other terrestrial wildlife will be considered separately.

3.1 Granular Carbofuran

All existing granular formulations of carbofuran are especially hazardous to birds. Registered rates of application range from 0.225 to 5.5 kg a.i./ha, but this difference in rate is probably of less consequence than the fact that a surplus of granules always seems to be available to birds under normal agricultural conditions. On the strength of the evidence to date, it does not appear that adequate mitigation of the hazard is possible. The impact on birds from the use of the registered granular formulations will continue to be extensive if those formulations are allowed to remain on the market. The main findings of this assessment with regard to the granular formulations of carbofuran are summarized below.

Routes of exposure

- Birds actively seek and consume carbofuran granules. The granules are approximately the same size as dietary grit, which consists of small pebbles or large grains of sand that are swallowed and retained in the gizzards of birds to aid in breaking down foodstuffs. Kills of birds resulting from the normal agricultural uses of granular carbofuran have shown conclusively that both the Furadan 10G and Furadan CR-10 formulations (two of the currently registered formulations sold in Canada) are consumed by birds. There is no reason to believe that the 5G is any less attractive to birds. The CR-10 and 5G granules, which are formulated on a corncob base, may also be attractive because of their value as food. FMC Corporation (the manufacturer of carbofuran) has documented kills of at least 45 bird species in the course of its own supervised field trials in corn (maize) fields alone.

- It has been demonstrated under laboratory conditions that a single granule of carbofuran can be lethal to a small songbird. Therefore, exposure need only be minimal to cause an impact. In a sample of 479 Horned Larks (*Eremophila alpestris*) found dead in a group of Utah cornfields treated with granular carbofuran, the median number of granules found in the birds' gizzards was two.

- The consumption of invertebrates, notably earthworms, is an additional route of exposure to granular carbofuran, because the granules can adhere to the invertebrates and contaminate their tissues. Based on residue levels found in earthworms from a cornfield, a realistic hazard assessment indicates that, at the lowest carbofuran application rate in corn, a single earthworm can be lethal to the songbird consuming it. Field studies have reported dead American Robins (*Turdus migratorius*), which feed primarily on earthworms. The contamination of nestlings of other songbirds in proximity to a treated cornfield has also been documented, indicating that contaminated invertebrates were being brought to the nest.

- Flooding or puddling of fields is another way in which several bird species have been killed by carbofuran granules. Problems have been especially severe in the heavy acidic soils of the lower British Columbia mainland but have also been reported elsewhere. Exposure can be through the sifting of contaminated soil slurries and direct ingestion of granules, primarily by waterfowl, or through drinking contaminated water.

- Secondary poisoning of eagles, hawks, vultures, and other birds of prey by granular carbofuran has been repeatedly documented under operational use conditions as well as in at least one supervised field trial. Here, we restrict the use of the term “secondary poisoning” to refer to the poisoning of a flesh eater feeding on the contaminated tissues of a vertebrate. As of September 1990, there were upwards of 30 documented incidents on record in the United States, excluding incidents involving intentional misuse of carbofuran products (cases in which carbofuran was shown to have been used in order to intentionally poison birds of prey). Large-scale secondary poisoning of vultures in South African cornfields has also been reported to the Canadian Wildlife Service. Secondary poisonings of a Red-tailed Hawk (*Buteo jamaicensis*) and of at least two Bald Eagles (*Haliaeetus leucocephalus*) have recently been confirmed in British Columbia; several more birds are suspected of having been similarly poisoned. It appears that most or all had been scavenging poisoned waterfowl in fields.

Engineering aspects

- Current planters and planting machinery used in row crops leave large numbers of exposed granules on the soil surface. For example, it is estimated that, under prevailing conditions in Ontario cornfields, between 515 and 1065 Furadan 10G granules are left on the soil surface per metre of furrow. The best possible incorporation of granulars, an in-furrow application in a laboratory setting, still leaves between 17 and 27 granules exposed per metre of furrow. Several studies and reports have shown that even in-furrow applications will not reduce bird mortality with a granular product as toxic as carbofuran, because a surplus of surface granules will always be available to foraging birds. Furthermore, birds habitually scratch the soil surface and probe the soil with their beaks while foraging and could obtain incorporated granules that way. Mortality has been reported even when no granules were found on the surface.

- Similarly, the prevailing type of seed drill used for canola (rapeseed) in western Canada leaves, on average, between six and 17 of the larger Furadan CR-10 granules on the soil surface per square metre of field, with “hot spots” as high as 33 granules per square metre.

Magnitude and frequency of kills

- On the basis of kill rates reported in company studies conducted in corn fields, it can be concluded that the use of granular carbofuran will result in the deaths of a large proportion of the songbirds breeding in and around treated fields.

This does not take into account the fact that the reported kill rates do not include birds that leave the field before dying or those that are scavenged or not found. There is also more limited evidence that small mammals are poisoned as well.

- Studies performed by the manufacturer of carbofuran in five different U.S. states, but under conditions typical of Canadian farming, have shown conclusively that the kill rate on carbofuran-treated corn fields is less a function of granule application technique than of the presence of birds in and around the fields. Even attempts to patrol freshly planted fields on foot and to manually cover granules did not succeed in reducing the hazard to birds. In-furrow applications of granular carbofuran (the method giving the best possible granule incorporation) under ideal conditions of calibration and supervision still gave rise to bird kills.

- Kill reports available from the operational use of granular carbofuran confirm the hazard already established by the available field studies. In addition, kill reports from granular carbofuran use on crops such as canola, potatoes, turnips, sugar beets and green peppers indicate that the problem with granular carbofuran extends to most, and probably all, existing registrations.

- The use of Furadan CR-10 on canola is probably the most serious current problem because of the potential for mass mortality of very large flocks of arctic migrants that traverse the northern prairies at canola seeding time. A large kill of Lapland Longspurs (*Calcarius lapponicus*) that occurred on a carbofuran-treated field in 1984 is thought to have taken place under conditions of granule incorporation that were better than those achieved with the most popular seeding implement. The number of birds in that incident was estimated at more than 2,000. This is thought to be an underestimate because this species travels north in very large flocks and carcasses were said to have been distributed over an entire quarter section (64 ha). Surveys have shown freshly seeded canola fields to be very attractive to a large number of bird species.

- Waterfowl and other water birds have repeatedly been poisoned when they have foraged in treated fields that were flooded or that developed puddles *months* after the pesticide application. In acidic soils, the granules can be particularly persistent and have remained lethal for upwards of seven months in a few well-documented instances, both in Canada and in the United States.

North American Status

- The U.S. Environmental Protection Agency (EPA) has recently announced a negotiated settlement with FMC Corporation to withdraw all but five minor uses of granular carbofuran in the United States. As stated by the EPA, “none of [the] risk reduction measures [evaluated by the EPA] were adequate to reduce the risk to birds, given the high toxicity of carbofuran granules.”

- The State of Virginia recently conducted an extensive survey that showed that bird kills were found in 33 of 44 treated cornfields despite such drastic risk reduction measures as wide buffer zones on the edges of fields, devices to shut off granule flow in turn areas, and extensive training programs for the applicators. A complete ban on granular carbofuran is now in effect in that state.

- The American Ornithologists' Union, one of the world's largest associations of professional ornithologists, passed a resolution in 1990 calling for the cancellation and immediate suspension of all carbofuran granular products and urging the U.S. government to also ban the liquid formulation of the insecticide.

3.2 Flowable Carbofuran

Exposure of wildlife species to the liquid (flowable) formulation of carbofuran is much more context-dependent and the likely hazard to wildlife species more variable than with the granular formulations. Rates of application of the liquid formulation range from 0.072 to 2.5 kg a.i./ha, or by a factor of 35, depending on the crop. Application may be by ground equipment or by air. A review of the evidence available to date helps to identify the main risk factors associated with carbofuran spray applications. An understanding of those risk factors allows for extrapolation to crops for which direct knowledge of the wildlife impact is unavailable. Knowledge of the principal risk factors also allows an assessment of the likelihood that mitigation of the risks associated with the liquid formulation could be successfully implemented.

However, the evidence indicates that it is very unlikely that the hazard of liquid carbofuran to wildlife could ever be eliminated completely. The toxicity of this insecticide is simply too high. Kills of birds recorded at the second lowest registered spray rate (132 g a.i./ha) leave little doubt that absolute safety is unattainable with this product. Studies carried out by the manufacturer at either 550 or 1100 g a.i./ha applied by ground rig, by air, or through centre-pivot irrigation systems suggest that kills of songbirds and also small mammals, reptiles, and amphibians are common and unavoidable. The extent of the kills is likely to be site-specific and may depend on the extent of field edge contamination and on the quality of the habitat surrounding the fields.

The main findings of this assessment with regard to the liquid formulation of carbofuran are summarized below.

Routes of exposure

- Laboratory studies indicate that a substantial fraction of an LD_{50} can be attained by songbirds feeding on contaminated grasshoppers and other invertebrates at one of the lowest registered spray rates (132 g a.i./ha). Measurements of brain cholinesterase inhibition in songbirds collected in a sprayed pasture confirm that the safety margin is limited or nonexistent at that rate.[3] Kills of gulls (*Larus sp.*) feeding on freshly sprayed grasshoppers have been recorded. This route of exposure is also the likely explanation for the impact of carbofuran on the Burrowing Owl (*Speotyto cunicularia*),[4] which is discussed in greater detail below. It must therefore be assumed that the potential for lethal intoxication of consumers of grasshoppers is always present following a grasshopper control program. This lack of safety margin is one of the greatest concerns given that the rate of carbofuran registered for grasshopper control is one of the lowest registered rates of application in Canada.

- A number of experimental studies indicate that dermal exposure of birds through overspray or contact with treated vegetation does not pose a significant hazard. This also appears to be the case for waterfowl, despite their apparent susceptibility to this insecticide. Mallard ducklings traversing areas where carbofuran had been applied at either 132 or 264 g a.i./ha were shown to be relatively safe provided they did not attempt to feed. There is evidence that overland movements by duck broods are rapid and that feeding is unlikely. However, concerns remain that any amount of feeding or pecking at the vegetation by the ducklings will almost certainly lead to incapacitation of the birds. Should some of the ducklings become incapacitated, the delay may result in the rest of the brood also being poisoned.

- A large number of kills of waterfowl have been reported in U.S. alfalfa fields when the birds have entered the fields to graze on the crop. Simple calculations show that alfalfa and other forage crops sprayed with carbofuran at the registered Canadian spray rates (0.132–2.5 kg a.i./ha) contain sufficient residues to kill grazing waterfowl. Data are lacking to indicate to what extent waterfowl and other species (e.g., grouse, pheasant, large mammals) are likely to graze on treated forage crops or in the margins of treated fields in Canada. At least one Canadian field study showed a significant impact of the grasshopper spray rate on small-mammal populations. Herbivorous species such as voles (*Microtus pennsylvanicus*) appeared to be the most affected, suggesting that exposure was primarily through grazing on contaminated vegetation.

- In Canada, there is at least one incident on record of waterfowl mortality resulting from exposure to contaminated puddles, following liquid carbofuran

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[3] *Because carbofuran inhibits cholinesterase enzymes, the measurement of the activity of this enzyme in brain tissue is a direct measure of the exposure of one of the key target sites to the insecticide. The extent of cholinesterase depression can be related approximately to the likelihood of fatal intoxication.*

[4] *This species was formerly in the genus Athene. The species name remains the same.*

treatment of a turnip field in British Columbia. Bird kills resulting from the use of carbofuran in drip water in U.S. vineyards are a well-documented problem, but this use pattern is not registered in Canada.

- Secondary poisoning of a bird of prey was also seen in one of the company's field studies. The extent to which secondary poisoning occurs with the flowable formulation is not known.

Burrowing Owls

- One of the most serious hazards of carbofuran flowable remains its demonstrated impact on the threatened Burrowing Owl. Research has shown conclusively that carbofuran applied at the grasshopper spray rate (132g a.i./ha) has a significant impact on the survival and reproductive success of Burrowing Owls. Significant declines in nesting success and brood size were seen with increasing proximity of carbofuran spraying to the nest burrow. There was no such trend of lowered reproductive indices with increasing proximity of spray for some of the main alternative insecticides to carbofuran (carbaryl, deltamethrin). Information available on likely routes of exposure (see above) strongly suggests that the hazard to Burrowing Owls is in direct proportion to the availability of contaminated prey items, either invertebrates or rodent species.

- Reports of owl colony abandonment following exposure to carbofuran were also provided by landowners. Analysis by the Canadian Wildlife Service also suggests that carbofuran use may have affected burrow reoccupancy in subsequent years.

- Removal of the product from the nesting range of the owl was initially proposed by the Canadian Wildlife Service following the field research that demonstrated the impact. In 1989, an interim regulatory decision was taken to label the product so as to prevent its use within 250 m of owl burrows. Unfortunately, despite an aggressive publicity campaign conducted by both the Canadian Wildlife Service and the manufacturer, knowledge of the new label requirement amongst users of the product is still not sufficient to achieve adequate protection of the species.

Evidence of an impact on songbirds and other vertebrates

- Studies on the effects of spraying flowable carbofuran at the registered grasshopper rate (132 g a.i./ha) on populations of roadside-nesting songbirds did not demonstrate any consistent impact. However, birds were found to forage away from the spray sites, and a number of deficiencies in the studies precluded definitive interpretation. A large pasture treated at the same low rate was also assessed postspray. Population surveys did not indicate major impacts on any of the common bird species. No conclusions could be reached regarding effects on the small-mammal populations with the information presented to date (full analysis of these data is not yet available). Birds in the spray block experienced very poor nesting success, but this is not thought to have been a treatment effect. Brain cholinesterase measurements indicated that a segment of the bird and small-mammal populations sustained life-threatening exposures, indicating little or no margin of safety.

- Studies involving the spraying of alfalfa fields at either 550 or 1100 g a.i./ha by ground and air were carried out by the manufacturer in the United States. (The lower rate of 550 g a.i./ha is close to the rate registered in Canada for corn, potato, peppers, and strawberries in eastern Canada. The applications to corn for the control of the European corn borer, *Ostrinia nubilalis*, are almost entirely aerial.) Spray deposits in the crop proper were low (e.g., averaging 23 percent only for the ground applications at the 550 g a.i./ha rate), but contamination of field edges was substantial. Songbird mortality was recorded at both application rates, whether the insecticide was applied by air or by ground. Most of the dead birds were associated with field edges. The level of field edge contamination did not differ substantially between the fields treated by ground or by air: six of 16 fields treated by ground application had maximum field edge deposits (presumably the downwind edge) higher than average in-field deposits; nine of 16 fields treated by air had higher edge deposits than in-field deposits. Secondary poisoning was also documented in the form of a paralyzed Northern Harrier (*Circus cyaneus*) feeding on a dead rabbit (*Sylvilagus floridanus*). Dead mammals, reptiles, and amphibians were also found. In Canada, a paralyzed bird was found on the edge of a strawberry field treated at 528 g a.i./ha.

- Further studies by the company involved the aerial application of carbofuran to cornfields at rates of 1100 g a.i./ha for the control of the European corn borer. This is approximately twice the rate registered for corn borers in Canada, although only two applications were made, whereas four are permissible in Canada. This rate of application is still lower than the rates registered in Canada for sugar beets, raspberries, strawberries in British Columbia, and cole crops. Application coverage was again very poor, with average deposits of 22 percent of applied; contamination of field edges was again documented. Despite the low measured rates of application, the spray again killed a number of songbirds. Others were found paralyzed. Other vertebrates were also killed, including four southern leopard frogs (*Rana sphenocephala*) found between two and six hours postspray along one of the field edges. A potential impact of carbofuran on amphibians is significant given the current concerns over their diminishing populations.

  It should be noted that some of the dead or paralyzed birds were found in the edges of control fields. However, residue analyses from those control field edges showed that they had received carbofuran contamination because neighbouring fields had been treated with the insecticide.

- Residue levels of 2 ppm carbofuran were measured in the gastrointestinal tracts of deer mice captured on treated sites. Similar levels were found in songbirds. The paralyzed Northern Harrier mentioned above was feeding on a rabbit carcass containing 0.1 ppm carbofuran. This raises the possibility that secondary poisoning is a widespread occurrence following the use of flowable carbofuran. However, the data do not currently allow us to make this determination because residues in the gastrointestinal tracts of small mammals or birds are not readily comparable to the total body burden measured in the rabbit carcass.

North American Status

- The flowable formulation of carbofuran has not yet been formally the subject of a special review in the U.S. although, informally, review activities have been taking place within the U.S. EPA and draft documents have been prepared in the anticipation of a review. As mentioned earlier, groups such as the American Ornithologists Union have been pressuring the U.S. EPA to take action on the flowable formulation.

- Some States have taken unilateral action to control the use of the flowable formulation within their jurisdiction. In California, the product is labelled so that it cannot be used within 1 mile (1.6 km) of any nesting waterfowl or on areas where grazing waterfowl may be expected to feed. Similar labelling in Canada would mean a virtual elimination of the product from the Canadian prairies. California has also imposed recent restrictions on the use of the product in vineyards.

- In Canada, a recommendation to eliminate the use of carbofuran from the entire (current and historical) range of the Burrowing Owl has now been put forth by the Canadian Burrowing Owl Recovery Team, a federal-provincial initiative to rehabilitate the species.

4.0 Assessment of the Value of Carbofuran to Canadian Agriculture

In response to the announcement of the carbofuran special review, Chemagro Ltd. and FMC Corp. (hereafter referred to as Chemagro/FMC) submitted two reports to support the value of carbofuran use to Canadian agriculture. These reports, entitled *An Economic Assessment of the Benefits of Granular and Liquid Formulation of Furadan in Canada* and *Furadan Benefits Assessment: Special Crops*, provided information on the economic and/or agronomic benefits of carbofuran use on specific crops. The first of these two reports included substantive input from the economic consulting firm of Deloitte & Touche, Guelph, Ontario (hereafter this report will be referred to as the registrant/D&T report). The two reports were reviewed by Agriculture Canada. The registrant/D&T report is summarized in subsections 4.2.1, 4.2.2, 4.3.1 and 4.3.2. Selected highlights from the other report are presented in subsection 4.4. The reader should refer to the original reports for details, textual sources and references.

Copies of the reports can be obtained from:

Chemagro Ltd.
77 Belfield Road
Etobicoke, Ontario
M9W 1G6

Also included in this section are comments from Policy Branch of Agriculture Canada regarding the assessment of the economic benefits of carbofuran as presented in the registrant/D&T report. These comments are contained in subsection 4.2.3 and 4.3.3. The economic benefits summarized below should be considered in light of the qualifications noted by Policy Branch.

4.1 Overview of Carbofuran Uses

Carbofuran is a carbamate insecticide with contact, stomach and systemic activity. It is highly effective against several economically important insect pests of major and special crops. Information on the registered products, registered uses, directions for use and use limitations are presented in Section 2.2 and Appendix 1. A description of the market sectors in which carbofuran is registered for use is shown in Table 5.

Table 5: Crop Production Statistics for Canada in 1990 (sources: Statistics Canada Catalogue 22-003, 22-002, 21-001)

Crop	Planted Area (hectares)	Production (metric tonnes)	Farm Gate Value ($ millions)
Barley	4,769,000	13,441,000	650
Oats	1,521,000	2,692,000	80
Flax	694,000	889,000	119
Sunflower	64,800	110,000	21.9
Wheat	14,098,000	32,098,000	3,079
Canola	2,529,000	3,266,000	793
Mustard	231,000	250,000	40.6
Sweet Corn	39,500	338,000	69.6
Field Corn	1,062,000	7,346,000	-[A]
Green Peppers	2,300	24,800	17.8
Potatoes	119,800	2,959,200	373
Sugar beets	24,300	942,000	42.9
Onions (dry)	3,800	130,000	25.1
Strawberries	-[A]	28,900	45.1
Raspberries	-[A]	14,200	15.7
Rutabaga	2,600	86,900	18.0

[A] not available

Although carbofuran is registered for use on a wide variety of crops, the largest uses of carbofuran, in terms of area treated and volume of product sales, are for grasshopper control in wheat and flea beetle control in canola.

4.2 Grasshopper Control in Wheat

4.2.1 Pest Problem and Current Control Practices

Over 14 million hectares of wheat are grown in Canada, primarily in western Canada. In 1990, more than 8 million hectares were planted to wheat in Saskatchewan compared with slightly more than 3 million hectares in Alberta and 2 million hectares in Manitoba. The farm value of the wheat crop in 1990 was $3 billion.

Grasshoppers are the most significant and extensive insect pest on wheat grown in western Canada. If left uncontrolled, grasshoppers have the potential of reducing crop yields by up to 32 percent in severe outbreak years. One estimate of the potential cost impact of a severe grasshopper outbreak in wheat in western Canada (e.g., 1985-86) is $156 million per year.

Grasshopper infestations are cyclical in nature. Fluctuations in the levels of infestation and the damage caused are primarily dependent on temperature and precipitation. The dry areas of the prairies, primarily southern Alberta and Saskatchewan and to a lesser extent southwestern Manitoba, are most susceptible to grasshopper infestations. The level of infestation often parallels drought conditions across the prairies. That is, grasshopper infestations tend to be most severe when the weather is hot and dry. In 1985-86, the grasshopper infestation in western Canada reached severe levels. Since then, populations have declined.

Current practices for control of grasshoppers involve foliar application of insecticides. Applications are usually made following egg hatch in the spring when newly germinated seedlings are at greatest risk. Insecticides may also be applied to roadside ditches and along field edges to prevent infiltration into fields. In situations with multiple hatches or migratory populations, multiple applications may be necessary to achieve adequate control. Besides carbofuran (Furadan 480F), several other insecticides are available for grasshopper control including dimethoate, deltamethrin, azinphos methyl, chlorpyrifos, malathion, cypermethrin and carbaryl; however, not all are used or marketed.

Information provided in the registrant/D&T report has shown that, in the years 1983-1990, carbofuran held the dominant market share for grasshopper control in wheat. The amount of Furadan 480F used on wheat during this period varied significantly, generally following the cyclical nature of grasshopper outbreaks. According to the registrant/D&T report, the dominant share of the market held by Furadan 480F can be attributed to its excellent control, very fast “knockdown” and low cost per hectare.

Extension personnel indicate that farmers tend to apply at least the mid-point of the label application ranges for most insecticide products (where applicable). On average, all treated hectares of wheat receive 1.5 applications of insecticides. Based on the above, the range in annual treatment costs for insecticides used for grasshopper control in western Canada were calculated and are presented in Table 6. It should be noted that particular prices may vary yearly and among dealers. Also, in years of grasshopper outbreak, insecticide applications may be subsidized by provincial governments; therefore the actual cost to the grower may vary.

Table 6: Range of annual treatment costs ($/hectare) for insecticides used to control grasshoppers on wheat in western Canada from 1983-90, assuming 1.5 applications per year at mid and maximum label rates (as reported in the registrant/D&T report)

Insecticide	Treatment Cost ($ per hectare)
Furadan 480F (carbofuran)	7.37 - 10.40
Sevin (carbaryl)	19.43 - 36.75
Decis (deltamethrin)	13.64 - 17.78
Cygon (dimethoate)	10.08 - 21.68
Lorsban 4E (chlorpyrifos)	12.38 - 20.18
Malathion (malathion)	12.50 - 15.15

Generally, research and extension specialists are somewhat mixed in their response regarding the effectiveness of Furadan compared with other products. Some researchers claim that there is no difference in effectiveness among the products listed above. On the other hand, extension personnel believe that because of its quick knockdown, Furadan is perceived to be more “effective” than other products, at least from the farmers’ perspective. Indeed, it was mentioned in the registrant/D&T report that farmers would continue using Furadan even without any price advantage because of its fast knockdown performance.

4.2.2 Loss of Furadan 480F for Grasshopper Control in Wheat

The registrants, in conjunction with the economic consulting firm of Deloitte and Touche, prepared an assessment of the economic costs associated with the removal of Furadan 480F for grasshopper control in wheat. A summary of the economic assessment is presented below.

The analysis covered an eight-year period from 1983 to 1990 in order to account for the cyclical nature of grasshopper infestations. Data and assumptions used in the assessment were derived and developed from a combination of two sources: 1) published scientific data and reports, and 2) expert consensus opinion of selected crop protection specialists. Initially, a preliminary assessment was prepared through consultations with 27 research and extension personnel and a review of available literature. Subsequently, a one-day seminar was held with a seven-person expert panel to receive suggestions for revision.

The magnitude of the economic benefit of carbofuran usage can be estimated by quantifying the economic costs that would be incurred if Furadan were removed from the market. Chemagro/FMC argue that the loss of Furadan for the purposes of grasshopper control on wheat would likely result in the following:

- Wheat producers would substitute other registered products (e.g., Decis, Lorsban, Sevin) for Furadan to control grasshoppers.

- On areas currently treated with Furadan, all substitute products would likely be applied at full label rates, in an attempt to duplicate the faster knockdown of Furadan.

- If Furadan were removed from the market for grasshopper control on wheat, it is possible that the prices of the remaining alternative insecticides could increase due to the less competitive environment that would exist in the absence of Furadan. The registrant/D&T report considered three price assumptions/scenarios regarding the price responses of alternative insecticides if Furadan were removed from the market: 1) no price response, 2) a 20 percent increase in prices; and 3) a 10 percent decrease in prices. These price response scenarios were determined with input from crop protection specialists. The registrant/ D&T report presented an economic analysis for each of the three price response scenarios.

- In the absence of Furadan, wheat growers would have to use more expensive and potentially less effective alternative insecticides for grasshopper control. This could result in:

  a) An increase in treatment cost resulting from the changeover from Furadan to higher cost alternatives. The registrant/D&T report estimates that there would be an increase in weighted treatment costs (i.e., weighted according to current market share of the remaining alternatives) of between 38 percent (assuming a 10 percent decrease in price of the alternatives) and

155 percent (assuming a 20 percent increase in price of the alternatives) depending on the year. This corresponds to an increase in treatment cost of $5.27 to $15.28/ha.

b) The registrant/D&T report assumes that for each 10 percent increase in average treatment cost per hectare there would be a two percent decrease in the area treated. That is, some currently treated areas would not be treated, resulting in additional crop loss. If Furadan was removed from the market, the registrant/D&T report argues that there would be a decrease in area treated for grasshoppers of between seven percent (assuming a 10 percent decrease in price of the alternatives) and 31 percent (assuming a 20 percent increase in price of the alternatives), in response to higher treatment costs. This decrease would result in additional crop loss on infested untreated areas of between 17 and 32 percent.

- If Furadan was removed from the market for grasshopper control on wheat, the registrant/D&T report estimates that the resulting cost to wheat producers would be as follows for each of the three product price response scenarios mentioned above:

a) With the scenario of no change in the price of the remaining alternative insecticides (considered, by the registrant/D&T report, a low probability scenario because Furadan is the least costly treatment and probably exerts downward pressure on market prices), the annual total cost to wheat producers (in constant 1990 dollars) would range from $1 million to $34.2 million, for an eight-year average of approximately $12 million per year. This cost to producers is composed of two elements: higher treatment costs and additional crop loss on the incremental untreated area.

b) With the scenario of a 20 percent increase in the product price for alternative insecticides, (considered by the registrant/D&T report as the scenario with the highest probability), the annual total cost to producers ranges from $1.4 million to $49.5 million, for an eight-year average of approximately $17 million per year. As above, this cost is comprised of higher treatment costs and additional crop loss.

c) In the event of a 10 percent decrease in remaining product prices, (a scenario with a low probability), the annual total cost impact ranges from $0.8 million to $25.9 million, with an eight-year average cost of approximately $9 million per year resulting from higher treatment cost and additional crop loss.

The following factors should also be considered:

- Regardless of the price response assumption taken, there would be a substantial cost impact to producers if Furadan is removed from the pest control market for wheat. Considering that Furadan is applied to other crops (e.g., barley, flax, oats) for grasshopper control, the cost impact to all crop producers would certainly be higher than that measured here for wheat alone.

- Over an eight-year period, the weighted benefit/cost ratio for grasshopper control on wheat with Furadan is 3.34, ranging from 1.03 to 4.81 in any given year. In high infestation years (1985-86), the benefit/cost ratio from grasshopper control is greatest, corresponding to the potential for significant crop loss if no controls are applied. In more recent years, the pressure from grasshoppers has been less and benefits of treatment are not as great as in high infestation years.

- Without Furadan, the benefit/cost ratio decreases to 2.12 (a 37 percent decrease relative to the current benefit/cost ratio of 3.34 with Furadan), without any price change in alternative products. With a 20 percent increase in the price of remaining alternatives, the benefit/cost ratio decreases to 1.67 (a 51 percent reduction in the benefit/cost ratio). With a 10 percent product price decrease, the ratio of benefits to cost fall to 2.38 (or by 29 percent).

4.2.3 Validity of the Economic Assessment - Policy Branch, Agriculture Canada

It should be noted at the outset that there is no single well-specified methodology which defines the proper manner for estimating the economic benefits of a pesticide. A significant element of judgment is necessarily involved in such efforts and there is typically more than one approach which can be thought of as reasonable. These general considerations apply fully to the economic assessment relating to carbofuran described in the preceding subsection.

As previously noted, a “two-phase” approach (involving a preliminary assessment and subsequent seminar) to obtain data and develop assumptions was used in preparing the assessment. This provides for an unusually high degree of confidence in the technical validity of the assumptions employed. Nevertheless, certain qualifications have been noted and are discussed below.

Area Treated Response

As previously noted, it is assumed that each 10 percent increase in treatment costs will lead to a two percent decrease in area treated. The particular ratio chosen clearly influences the results of the study. While no basis is evident for questioning the expert panel's judgment that a 10:2 ratio is appropriate, it may have been useful to employ at least one alternative assumption in order to determine the extent of the sensitivity of the results to the ratio chosen.

Interpretation of Increased Treatment Costs associated with the 20 percent Price Increase Scenario

Special care is required in interpreting the results which flow from the 20 percent price increase scenario, which is the scenario deemed by the registrant/D&T report to be the most likely.[5] A distinction can be drawn between costs associated with price increases due to pesticide producers taking advantage of less competitive market conditions and costs associated with inherently more costly pesticides necessarily being employed. In the former case, the extra dollars spent by growers as a result of the price increase represent, in essence, a transfer from growers to certain pesticide producers. In the latter case, the extra dollars spent by growers represent an expenditure of real economic resources or, in other words, a cost to the economy as a whole. The transfer described in the first case may or may not be desirable but the loss of real economic resources associated with the latter case is, without question, a loss in terms of overall economic welfare.

The above does not imply that scenarios involving price increase responses are irrelevant or inappropriate. However, the above distinction should be kept in mind when considering the importance of those costs which represent extra dollars spent due to pesticide price increases. To illustrate this, consider the total cost impact associated with the 20 percent price increase scenario. As indicated earlier, the average annual magnitude of this impact would be $16.6 million, with $11.9 million of this amount being the estimated value of crop loss and the remaining $4.6 million being the increase in treatment costs. The $11.9 million crop loss clearly represents a real economic loss. In addition, some portion of the $4.6 million reflects additional costs which would be incurred even if there was no price increase and, accordingly, also represents a real economic loss. However, the remaining portion is a transfer, as discussed above, from growers to certain pesticide producers. The size of this transfer has been calculated to be approximately $3.8 million. This implies that approximately $12.8 million of the total cost impact of $16.6 million represents a loss in real economic welfare.

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[5] *A similar level of care is required in interpreting the results associated with the 10 percent price decrease scenario. However, this will not be discussed here given the low probability of this scenario.*

Interpretation of Benefit/Cost Ratios

Some caution should be employed in considering the benefit/cost ratios presented in the preceding subsection because the extent to which they are informative may be limited in this context. The key quantitative question here is the extent to which aggregate economic benefits of a given use of carbofuran exceed the aggregate economic costs with respect to this given use. Clearly, the preceding subsection provides some useful estimates relating to this question. However, the benefit/cost ratios do not shed much additional light.

The limited relevance of such ratios is evidenced by the fact that one could easily envisage a situation in which a pesticide had a high benefit/cost ratio but low net benefits because, for example, it was used to a very limited extent. In such a case, the key fact would clearly be the small net economic benefits provided by the pesticide. If one did wish to express net economic benefits in some alternative form, they could be expressed as a percentage of the income of the growers in question.

Similarity of Treated and Untreated Areas

There is an assumption employed in the assessment that is not mentioned previously in this document. It is that areas left untreated as a result of increases in pesticide treatment costs are, in terms of the potential benefits of pesticide usage in these areas, no different from areas which continue to be treated. In other words, untreated areas are similar to a random subset of all areas. This assumption runs counter to what might be expected. One would expect that growers would tend to leave untreated those areas where the benefits of pesticide use are the lowest. However, the importance of this tendency is mitigated by, among other things, the fact that the benefits of pesticide use are not believed to vary greatly from area to area. Accordingly, if a different assumption were employed, the ultimate effect on the results of the study would likely be quite small. Nevertheless, it should be noted that any such effect would reduce the magnitude of estimated benefits.

Other Assumptions

Two other assumptions employed in the assessment but not mentioned previously are the following:

- It is assumed that there are no non-chemical controls that are likely to be available in the relevant time horizon for the control of grasshoppers in connection with wheat.

- There is little potential for growers to respond to the removal of carbofuran by growing crops other than wheat.

Overall, the results of the assessment reflect a significant effort to assemble information for the purpose of identifying the benefits in question. They provide useful and balanced evidence of the nature and general magnitude of the economic benefits of carbofuran use in connection with the protection of wheat from grasshoppers. They should, however, be considered in light of the qualifications which have been noted above.

4.3 Flea Beetle Control in Canola

4.3.1 Pest Problem and Current Control Practices

Canola is grown on almost 3 million hectares in Canada, primarily in the three prairie provinces. In 1991, in excess of 1.3 million hectares were planted with canola in Saskatchewan, followed by Alberta with greater than 1.2 million hectares and Manitoba with close to 0.5 million hectares. The total value of the Canadian canola crop in 1991 was $792 million.

The most significant insect pest on canola, in terms of extent and intensity of infestation, is the flea beetle. Flea beetles are a chronic pest problem wherever canola is grown in the prairie provinces, but particularly in Manitoba and eastern Saskatchewan.

Factors which influence expected levels of damage include overwintering populations of adult flea beetles, overwintering conditions, and spring moisture and temperature conditions. In Manitoba, population pressure is relatively constant, with only minor fluctuations; consequently preventive measures are common. Early seedling protection is critical to prevent crop damage and subsequent yield losses.

Feeding by adult beetles on cotyledons and young leaves in the spring is the major cause of crop loss. High populations of flea beetles, when associated with poor plant growth due to hot dry weather, can destroy the crop forcing farmers to re-seed or leave the land in fallow. At the present time, insecticides are the only method available for control of this pest. Research is being conducted on biological control measures and plant resistance or tolerance to flea beetles. However, it may be some time before such alternatives are available to the producer.

The risk of crop loss, if no control measures are taken, is extensive. Manitoba has the most severe flea beetle problem of the three prairie provinces, but on the whole, accounts for approximately 16 percent of canola production. Potential crop losses have been estimated to be as high as 23 to 52 percent in Manitoba, 18 to 32 percent in Saskatchewan, and 10 to 17 percent in Alberta, when averaged across all crop conditions and infestation levels. It is estimated that the annual value of canola crop losses could approach $40 million in Manitoba if no flea beetle control measures are applied. Because of this risk, close to 100 percent of the planted canola area receives some form of insecticide treatment.

There are three types of chemical control currently available to the producer for control of flea beetles on canola:

1) various formulations of seed treatments containing the insecticide lindane, as well as one or more fungicides;

2) in-furrow application of a granular insecticide, either Furadan (5G or CR-10) or Counter (terbufos);

3) post-emergence foliar application of an insecticide. Products registered for this use include Furadan 480F, Sevin, Decis, Lorsban, and Malathion.

A summary of the average annual treatment costs for insecticides used to control flea beetles on canola in western Canada is presented in Table 7. It should be noted that the price for a given product may vary yearly and among dealers.

Table 7: Range of annual treatment costs ($/hectare) for insecticides used to control flea beetles on canola in western Canada from 1983-90 (as reported in the registrant/D&T report)

Insecticide	Treatment Cost ($ per hectare)
Seed Treatment (containing Lindane):	
Vitavax	6.49 - 7.25
Rovral	6.76 - 8.98
Benolin	4.10 - 5.36
Thiralin Plus	3.76 - 4.99
Gammasan Plus	3.76 - 4.99
Granular Treatment:	
Furadan (carbofuran)	12.21 - 14.14
Counter (terbufos)	12.87 - 20.38
Foliar Treatment:	
Furadan (carbofuran)	3.69 - 6.02
Decis (deltamethrin)	9.09 - 11.00
Lorsban (chlorpyrifos)	11.31 - 15.29
Malathion (malathion)	5.39 - 6.53
Other	5.04 - 6.82

Seed treatments containing lindane generally provide control for up to one week after seedling emergence. Control can be extended up to two weeks with the use of a granular insecticide (i.e., Furadan or Counter). Foliar sprays can be used as a follow-up treatment. Growers may use a combination of treatments to ensure crop protection, depending on the level of infestation generally expected in their area. In Manitoba and eastern Saskatchewan, where flea beetle populations are most severe, growers will use a lindane seed treatment for control in the first few days of germination and a granular treatment for continuing/longer-term control. The granular insecticide is typically applied in-furrow along with the lindane-treated seed. A follow-up (post-planting) foliar insecticide may also be applied in extreme situations, particularly in cases where there is insufficient moisture to fully activate the granular.

In the northern and western regions of the prairie provinces where flea beetle populations are less severe, growers rely primarily on the use of lindane-treated seed and, in some situations, follow up with a foliar spray as required. In some cases, a granular insecticide may be applied around field edges to prevent flea beetles from infiltrating crop areas.

Between 1980 and 1985, chemical control of flea beetles in canola relied primarily on the use of lindane-treated seed. Data indicate that between 10 and 20 percent of the total canola crop in western Canada was treated with a granular insecticide from 1983 to 1990. According to the registrant/D&T report, granular Furadan is applied to approximately 50 percent of the total granular treated area, with Counter applied to the remaining areas. The data also indicate that during the same period (1983 to 1990), foliar insecticide sprays were applied to between nine and 14 percent of the total canola crop, primarily as a rescue treatment. Approximately 50 to 95 percent of the canola receiving a foliar treatment is treated with Furadan 480F.

4.3.2 Loss of Furadan (both Granular and Flowable) for Flea Beetle Control on Canola

The registrants, in conjunction with the economic consulting firm of Deloitte and Touche, prepared an assessment of the economic costs associated with the removal from the market of the granular (5G, CR-10) and flowable (480F) formulations of carbofuran for flea beetle control in canola. A summary of the economic assessment is presented below. The methodology and sources of information used by the company in their assessment were the same as those used in preparation of the economic assessment for wheat, section 4.2.2. (i.e., published scientific data and reports, and expert opinion of selected crop protection specialists).

The registrants argue that the loss of both the granular and flowable formulations of Furadan from the market for flea beetle control in canola would likely result in the following:

- Growers would substitute Counter (terbufos) for Furadan 5G and CR-10 in the granular treatment portion of the flea beetle control market. However, because Counter and Furadan each currently have approximately 50 percent share of the granular market in canola, the loss of Furadan granules would subject the grower to less competitive single supplier economics.

- Other registered insecticides (e.g. Sevin, Decis, Lorsban, Malathion) would be substituted for Furadan 480F for foliar treatments.

- The registrant/D&T report assumes that each 10 percent increase in average treatment costs per hectare would result in a two percent decrease in the area treated. Therefore, if both granular and flowable Furadan were removed from the market, there would be a marginal decrease in the area treated with granular and foliar insecticides as a result of the higher costs of the alternative insecticides compared with Furadan. This area not treated with granular or foliar insecticides would now receive only the basic seed treatment. Consequently, there would be additional crop loss on areas cut back to seed treatments only from granular and/or foliar applications.

- If Furadan products were removed from the market, it is possible that the prices of the remaining alternative insecticides could increase because of the less competitive environment that would exist in the absence of Furadan. The registrant/D&T report considered the following two scenarios for the price responses of alternative insecticides if Furadan were removed from the market: 1) no change in the product price of the remaining alternatives, and 2) a 50 percent increase in the product price for Counter and a 20 percent increase in the product price for remaining foliar insecticides. The 50 percent and 20 percent increase figures were derived with input from crop protection specialists (Note: These scenarios consider that both the granular and flowable formulations of carbofuran are removed from the market. The registrant/D&T report did not consider the possibility that only one of the formulations, either the granular or the flowable, would not be available). The estimated cost to canola producers would be as follows:

  a) Assuming that there is no product price increase for Counter and the other foliar insecticides, the total annual cost to producers would range from $0.6 to $2.9 million for an eight-year average of $1.5 million per year. This average annual cost impact is comprised of $0.8 million in higher treatment costs associated with the current higher price of alternative insecticides; the remaining $0.7 million is the additional crop loss associated with some farmers switching from granular treatments and seed treatments to basic seed treatments only. This would occur given that Counter is marginally more costly to apply than Furadan, and some farmers would be unwilling to pay this higher cost to use a granular treatment.

b) With the scenario that the product price for Counter increases by 50 percent, and other foliar insecticides increase by 20 percent, the total annual cost to canola producers ranges from $4.7 million to $10.1 million, for an eight-year average of $6.8 million per year. This is comprised of $3.6 million in additional treatment cost and $3.2 million lost crop value.

- The vast majority of these cost impacts for flea beetle occur in Manitoba, because that province uses the highest level of granular applications.

- The current annual benefit/cost ratio for flea beetle control on canola in western Canada ranges from 2.85 to 4.74. Without Furadan on the market, the yearly ratio of benefits to costs decreases marginally to between 2.61 and 4.62 (a nine to three percent decrease, respectively). This is based on the assumption that prices for alternative insecticides do not increase. However, if prices for remaining products do increase, the annual benefit/cost ratio falls to between 2.03 and 3.55 (a 29 to 25 percent decrease).

4.3.3 Validity of the Economic Assessment - Policy Branch, Agriculture Canada

The methodology employed in deriving the economic benefit estimates of the preceding subsection is essentially the same as that used in estimating the economic benefits of carbofuran in connection with the protection of wheat from grasshoppers. Accordingly, the comments and qualifications contained in subsection 4.2.3 are equally applicable here. In summary, the results of the preceding subsection provide useful and balanced evidence regarding the nature and general magnitude of the economic benefits of this particular use of carbofuran; however, they should be considered in view of the qualifications noted in subsection 4.2.3.

4.4 Special and Minor Crop Uses

In addition to the information pertaining to wheat and canola, Chemagro/FMC submitted the report *Furadan Benefits Assessment: Special Crops* regarding the value of carbofuran to the production of other crops. The information provided in this report included input from independent researchers and crop extension specialists. Unlike the registrant/D&T report, which pertains primarily to the uses on wheat and canola, the information in this report is primarily qualitative rather than quantitative in nature.

The information provided by Chemagro/FMC indicates that the production of certain other crops could also suffer from the absence of carbofuran. Crops which would be affected include alfalfa, sweet and field corn, green peppers, potatoes, sugar beets, strawberries, dry onions, rutabagas and sunflowers. Although the area over which these crops are grown is smaller than that for wheat and canola, the per hectare value of the crop is considerably greater (Table 5). Therefore, these crops may be considered minor in terms of sales of Furadan, or total volume of Furadan applied to the crop, but not necessarily minor in terms of the value of Furadan use to the grower or the local economies where the crops are grown.

Furadan products are registered for control of numerous insect pests on a variety of crops (Appendix 1). The estimated average yield losses due to some of these insects if insecticide treatments (Furadan or other) were not made is presented in Table 8. These estimates were obtained from published information and input from extension entomologists and researchers. The level of insect infestations affecting these crops may vary annually and regionally and the insect infestations tend to be non-cyclical in nature. Therefore, the yield loss values presented in Table 8 could be considered typical for any given year.

Table 8: Estimated annual yield loss from certain insects for selected crops for which Furadan is registered (yield loss if insecticide treatments, Furadan or other, were not made).

Crop	Insect Pests	Average Percent Yield Loss
Potato	Foliage insects	58.1
Sweet Corn	European Corn Borer	64.4
Strawberries	Strawberry Clipper Weevil	27.5
Sugar Beets	Sugar Beet Root Maggot	37.5
Onion (dry)	Onion Maggot	39.3
Sunflower	Sunflower Beetle	8.5
Rutabaga	Root Maggot	58.2
Green Peppers	European Corn Borer	9.2
Field Corn	European Corn Borer	14.3
Raspberry	Raspberry (Bud or Root) Weevil	50.0

The specific pest(s) and the nature and extent of the economic benefits of carbofuran vary considerably from crop to crop. Economic benefits may take the form of higher yields, higher levels of quality and/or lower treatment costs.

In some cases, carbofuran is a useful tool in the management of resistance to insecticides. Rotation in use among classes of chemical insecticides (e.g., carbamates, organophosphates, synthetic pyrethroids, chlorinated hydrocarbons) is often recommended to delay or avoid the selection for resistant pest populations. Carbofuran could play an important role in resistance management in situations where it is the only effective carbamate insecticide available for use on a given crop.

Although effective alternatives to carbofuran are available for use on some of these crops, in some cases the number of alternative insecticides are few. Because of the high cost to register new active ingredients, there is often little economic incentive for companies to develop new insecticide products in crops where the market is small. Therefore, loss of Furadan in these situations could have long-term negative consequences on insect pest management in certain crops.

Information on the benefits of carbofuran to selected crops is presented below:

Alfalfa

Alfalfa is grown in all regions of Canada for forage and seed. Alfalfa weevil is one of several important insect pests on alfalfa. Alfalfa grown for seed is sometimes treated with an insecticide for control of weevil. Alfalfa grown for forage is treated less often. Furadan 480F is effective against the alfalfa weevil and, according to the company report, is more cost effective compared with the registered alternatives (e.g., phosmet, malathion).

Onions (dry)

The onion maggot is the most damaging insect pest of onions and, if left uncontrolled, can prevent the production of a marketable crop. Furadan 10G can be applied in the seed furrow at planting for control of first generation larvae in areas where resistance is not a problem. In the Bradford Marsh area of Ontario, Furadan 10G is not used because it is apparently broken down very quickly in the muck soil and is less effective than alternative products. Growers rely on foliar sprays of organophosphorous or synthetic pyrethroid insecticides for control of subsequent generations of onion maggot.

Sweet Corn

Sweet corn production in Canada in 1990 totalled 337,987 metric tonnes and was planted on 39,479 hectares, mostly in Ontario (23,000 ha) and Quebec (12,000 ha). The total farm gate value in 1990 was more than $69 million.

European corn borer (ECB) is one of the main insect pests on sweet corn in Canada and, if left uncontrolled, can cause yield losses of up to 64 percent. Population pressure is particularly high in the areas of southern Ontario and Quebec where both single and two-generation strains of this insect occur. These geographic areas also contain the highest area of sweet corn.

Furadan 480F is one of the most cost effective products for ECB control and, based on information supplied by the registrants, holds the dominant market share. Alternative products available include synthetic pyrethroids, carbaryl and methomyl. In Ontario, Furadan 480F is often applied to corn by air. Applications of insecticides to sweet corn for control of ECB are made from mid-June to early August when day-time temperatures are relatively high. Because of their temperature sensitivity, synthetic pyrethroid insecticides tend to be less effective than Furadan 480F when applied during hot weather. Carbaryl is generally not used for control of corn borer in sweet corn because bees foraging for pollen may carry the insecticide back to the hive where the brood may be exposed. Also, the residual period for carbaryl is considered shorter than that afforded by carbofuran.

Loss of carbofuran would reduce flexibility in choosing chemical control options and would require growers to use more expensive and/or less effective products. Either could lead to increased costs to growers.

Green Peppers

Peppers are not a preferred host for ECB but will sustain infestation levels as high as 20 percent. Buyers will only accept peppers with very low infestations of ECB (less than 1 percent, if possible). Because of the difficulty in sorting out infested from non-infested produce, the total production of green peppers could be rejected even if infestations are relatively low.

Furadan 480F is the most commonly used insecticide for control of corn borer in Ontario. It is favored by growers because it is considered to have longer residual action than alternative products and because it also suppresses aphids.

The loss of Furadan 480F would limit the choice of insecticides to carbaryl and the synthetic pyrethroids deltamethrin and permethrin. Because of the limitations of the alternative materials (shorter residual period and toxicity to bees for carbaryl; lower effectiveness at high temperatures for the synthetic pyrethroids), control of the ECB could become more difficult, encouraging more applications of insecticides. This could result in increased costs to the grower. Also, the loss of Furadan 480F could lead to more rapid selection for pest populations which are resistant to the registered alternative insecticides.

Potatoes

Potatoes are grown in all provinces and cover a total area of 119,800 hectares (1990). Total production in 1991 was 2.9 million metric tonnes representing a farm gate value of $373 million. Most potatoes are grown in Prince Edward Island (29 percent), New Brunswick (20 percent), and Quebec (13 percent). Without treatment, crop losses due to insect pests can average more than 50 percent.

Colorado potato beetle (CPB) is the most destructive insect pest in potatoes. It is a major problem in Ontario, Quebec, and the Maritimes where population pressure is high. Resistance to insecticides, including carbofuran, is relatively widespread in eastern Canada. In western Canada, the population pressure of CPB is lower and, at this time, resistance is not a problem. Rotation among insecticides of different chemical groups is the most common method of resistance management.

Carbofuran is effective for control of CPB, where resistance is not a problem. It is also effective for control of other potato insect pests such as flea beetle, leafhopper and tarnished plant bug. Besides the carbamate carbofuran, two organophosphorous insecticides (phorate and disulfoton) are the only granular insecticides available for early season control of potato pests. Loss of Furadan 10G could increase the selection pressure for resistance to the remaining organophosphorous granular insecticides. Alternative foliar spray insecticides from four classes of chemical insecticides (i.e. organophosphate, synthetic pyrethroid, carbamate, chlorinated hydrocarbon) are currently available for in-season control of insect pests of potato.

Alternatives to traditional chemical insecticides are available for control of certain insects on potatoes. The biological insecticide *Bacillus thuringiensis* is available for control of CPB. Also, careful cultural practices can reduce insecticide requirements in potato production. For example, crop rotation can reduce CPB levels or avoid wireworm infestations and timely vine killing can reduce overwintering CPB populations.

Loss of Furadan 10G would have little impact in areas of established CPB resistance to carbofuran. However, in areas where resistance is not established, loss of Furadan 10G could have a greater impact because this would increase the selection pressure for resistance to the remaining granular insecticides, both organophosphates. Also, loss of Furadan 10G could lead to a greater reliance on foliar sprays. If Furadan 480F were removed from the market, growers could still rotate among four classes of chemical insecticides for application as a foliar spray.

Rutabagas

The cabbage root maggot is the most damaging insect pest in rutabagas. Without insecticide treatments, it is estimated that losses due to the cabbage root maggot can reach 50 percent or higher. Insecticides used for control of root maggot are applied to the soil to prevent oviposition and to kill newly hatched larvae before they can attack the roots. Because there may be three or four generations of root maggots per year, control measures may be necessary thought the growing season.

Current control practices for root maggots call for either application of a granular insecticide during seeding or application of an insecticide as a drench spray over the row just prior to plant emergence. An additional one or two drench sprays may be required later in the season for control of subsequent generations of root maggots. Granular products registered for control of root maggots in rutabagas include Furadan 10G, Lorsban 15G (chlorpyrifos) and Counter 15G (terbufos). Products registered for in-season use as a drench treatment include Furadan 480F, Lorsban 4E (chlorpyrifos) and Birlane 40 EC (chlorfenvinfos). Loss of either Furadan 10G or Furadan 480F would have little immediate impact on rutabaga production due to the availability of alternative insecticides. However, all of the alternative insecticides are organophosphorous chemicals which could lead to the development of resistance problems should both Furadan 10G and Furadan 480F be removed from the market.

Strawberries

The strawberry blossom clipper weevil can cause significant damage to the strawberry crop in Ontario and Quebec which represent the largest areas of strawberry production in Canada. Furadan 480F is one of the two products currently recommended for control of this pest, the other being cypermethrin (1990-1991 Fruit Production Recommendations, Ontario Ministry of Agriculture and Food). Both insecticides are effective against the strawberry blossom clipper weevil. Although both Furadan and cypermethrin are broad spectrum in their activity, Furadan tends to be less harsh on mite predators than cypermethrin. If Furadan 480F were removed from the market, growers would probably rely solely on cypermethrin for control of strawberry blossom clipper weevil which could lead to a build-up in mite populations and the need for increased use of miticides.

Sugar Beets

Sugar beet root maggot is a problem only in Alberta. The granular insecticides, Furadan 10G and Temik (aldicarb) applied in-furrow at planting, and Furadan 480F applied as a drench over the row are currently the most favored control measures.

4.4.1 Loss of carbofuran

The economic benefits for crops other than wheat and canola have not been meaningfully quantified. However, the limited quantitative evidence provided in the registrants' reports does suggest that the magnitude of the economic benefits of carbofuran usage is greater for some of these crops than for others. The economic benefits of Furadan may be greatest in those crops for which control options are already limited (e.g., control of European corn borer in sweet corn and green peppers during hot weather; control of strawberry clipper weevil in strawberries).

5.0 Regulatory Options

In determining regulatory decisions under the authority of the *Pest Control Products Act*, there are a number of regulatory options available to deal with identified problems. In the case of carbofuran, a list of possible regulatory options are presented below. Accompanying each option statement are supporting factors and consequences. The options are presented from the least to the most restrictive in terms of future carbofuran use. However, the regulatory options as presented are not necessarily mutually exclusive (i.e., more than one regulatory option could be imposed upon a given use of carbofuran if appropriate).

There are, undoubtedly, alternative and derivative options regarding the future registration status of carbofuran and its registered uses which are not presented in this document. Those parties interested in commenting on this matter, or in putting forth other regulatory options, are invited to do so.

It should also be noted that the Special Review of carbofuran and the following regulatory options apply only to the uses of the currently registered carbofuran products. The Special Review in no way affects any new uses or new formulations of carbofuran which may be proposed at some future time. The acceptability for registration of any such new uses or new formulations of carbofuran would be evaluated on the basis of the product's own safety, merit and value.

As presented in Sections 3 and 4 above, the various uses of carbofuran differ with respect to the potential for impact to wildlife and the value to agriculture. Therefore, each use of carbofuran will be considered separately when considering its future regulatory status. Following the regulatory options are a list of the registered uses of carbofuran, together with comments on the associated risks to wildlife, the value to agriculture, and suggested measures for mitigating risk to wildlife specific to that use. Each use should be considered separately when considering the general regulatory options.

Option 1. Maintain the use but improve the label to highlight precautionary statements to mitigate risk to wildlife.

Comments:

- Current carbofuran labels already contain information warning users about the high toxicity of the product to wildlife.

- Given the high toxicity of carbofuran to wildlife, it is unlikely that this option will reduce the incidence of wildlife mortality.

- This option would allow users continued access to the product with no obligation to alter current practices and with no economic hardship.

Option 2. The product would be classified as RESTRICTED and the user would be required to seek approval from provincial pesticide regulatory authorities prior to use. The following use restriction would appear on the label: "This product is to be used only in the manner authorized. Consult local pesticide regulatory authorities regarding use permits which may be required."

Comments:

- The *Pest Control Products Regulations* allow for designation of a product as RESTRICTED where there are concerns for the safety of animals and the environment, and allow for limitations to be set on the distribution and use of the product. Furadan 480F is currently classified as a RESTRICTED product with the restrictions being (1) that the product be stored separate from food and feed, and (2) that the product not be applied within 250 meters of burrowing owl nests. The granular formulations are not classified as RESTRICTED.

- This option would require provincial agreement and support as a pre-requisite. Some provinces may not have a system currently in place to handle such a permit system. There would be a cost to the provincial regulatory system in the letting of permits.

- This option would allow for continued use of the product where and when provincial authorities agree with the need for carbofuran use and where they have reasonable assurance that adverse impact on wildlife could be avoided or carefully controlled. However, this raises a question of jurisdiction. Certain species, and the attending biological expertise, are largely provincial (e.g., the Burrowing Owl). However, others, such as migratory bird species, fall under federal jurisdiction. Therefore, the provinces may not be in a position to comment on adverse impacts to species not under their jurisdiction.

- Where a use permit is denied, this may lead to local increases in input costs or to the need to change pest control methods on the part of growers and field extension personnel.

Option 3. Place restrictions on how the product may be used for the given crop/ pest combination.

Comments:

- In situations where the impact to wildlife in field edges is of concern, the prohibition of application by aircraft and the implementation of drift control measures (e.g., use of spray skirts on ground equipment) could reduce the risk to wildlife.

- The implementation of set-backs (i.e., no spray zones) around field edges could reduce the impact to wildlife in field edges.

- The practicality of these risk-reduction measures may not be known in terms of implementation and enforcement. Additional data may be required to demonstrate that a given measure is effective in reducing the impact to wildlife.

- There may be a cost to the users who have to change their current application practices.

Option 4. Where appropriate, place strict limitations on the use in specified geographical areas where the risks to wildlife are deemed to be unacceptable.

Comments:

- This option would ensure that carbofuran products are still available to users where the risks to wildlife are deemed acceptable, but would eliminate use in identified high risk areas.

- This option may present users with an increase in input costs in areas where the product is prohibited.

Option 5. Suspension of the use of carbofuran.

Comments:

- Section 20 of the *Pest Control Products Regulations* states that "the Minister (of Agriculture) may ... cancel or suspend the registration of a control product when, based on current information available to him, the safety of the control product ... is no longer acceptable to him." Suspension of the product would mean that the registrants, FMC Corp. and Chemagro Ltd., could not sell the product. However, existing stocks at the distributor, retailer and grower levels could be sold and used for a period of time to be established (e.g., to the end of the current registration period, 31 December 1995).

- This option would allow a period of time for users to change their approach to pest control by shifting to alternative chemical or non-chemical control strategies.

- This may present users with a gradual increase in input costs as users shift to alternative pest control measures.

- The risk to wildlife associated with a given use would be decreased over the next few years as remaining stocks of product are exhausted and users shift to alternative pest control measures.

Option 6. Immediate cancellation of the use of carbofuran.

Comments:

- The importation, sale and use of carbofuran for that purpose would stop immediately.
- This option would result in a disposal problem for users and retailers with current inventory of product.
- This option may result in an immediate increase in input costs to the user.
- The risk to wildlife associated with a given use would be immediately eliminated.

5.1 Registered Uses of Granular Carbofuran (5G, 10G, CR-10) Formulations and Associated Comments for Consideration of Regulatory Options:

The registered uses of granular carbofuran have been grouped below, largely on the basis of the use pattern and the agricultural value as presented by the registrants. However, this does not mean that the chosen regulatory options necessarily have to be the same for each crop within these groups. In their risk analysis, CWS argued that:

1) the three granule types are largely equivalent as to their relative hazard to birds. One to a few of the 5% or 10% granules are reported to be lethal, or are calculated to be lethal, to small birds.

2) the rate of application, unlike the situation with the flowable, does not have a strong bearing on the hazard to wildlife. Reasons for this are that a) exposure is often through selective direct uptake of whole granules, b) individual granules of any given formulation always carry the same amount of carbofuran regardless of the application rate, and c) those types of planting machinery that have been investigated have all been shown to leave a surplus quantity of granules on the soil surface. Application rate may be a relevant consideration where exposure is not through direct granule uptake (e.g. the case of puddling or flooding of fields where a higher application rate is expected to yield higher concentrations of the insecticide in water).

5.1.1 All uses of granular carbofuran on canola and mustard.

- The CWS consider this to be a particularly high risk situation because of the risk to large flocks of migrating birds that land in freshly treated fields.
- Data exist to show that current planting machinery leaves exposed granules on the soil surface and that the granules are attractive to birds. This evidence comes from engineering studies performed on seed planters and from an actual reported kill.

- These uses of granular carbofuran pose a high risk of secondary poisoning to raptors because of their high density in western Canada.

- Granular carbofuran is highly effective for flea beetle control in canola. If granular carbofuran were removed from the market, growers who usually apply a granular treatment would either rely on the remaining alternative granular insecticide (i.e., Counter) for flea beetle control or not treat with insecticide. This could result in an increase in production cost depending on the price response of Counter to removal of carbofuran from the market.

5.1.2 All uses of granular carbofuran on potatoes, turnips, rutabagas and sugar beets.

- The rates of application of granular carbofuran in potatoes, turnips and rutabagas are the highest registered (i.e., 2.5-3.6 kg a.i./ha for turnips and rutabagas, 3.25-5.5 kg a.i./ha for potatoes). The application rate is lower for sugar beets (i.e., 0.85 kg a.i./ha).

- Turnips and rutabagas are generally grown in heavy soils which are prone to puddling and/or flooding. In some regions (e.g., B.C.), potatoes are also grown in heavy soils. The irrigation of sugar beet crops following treatment may also be conducive to puddling. The CWS has identified puddling in treated fields as a clear hazard to wildlife. There are documented kills in turnip, rutabaga and potato fields. Bird kills have been documented in sugar beet fields in the United Kingdom, however, there are no data on the safety of this use pattern in Canada or the United States.

- Secondary poisoning of eagles and other raptors has been reported when these birds fed on waterfowl or songbird carcasses in treated turnip, rutabaga and potato fields.

- The registrants, FMC Corp. and Chemagro Ltd., have voluntarily stopped the sale of granular carbofuran in B.C. during the past few years in response to concerns over the impact on wildlife.

- Loss of granular carbofuran for use on potatoes could lead to a development of resistance to the two remaining granular alternatives, both of which are organophosphorous insecticides.

- Loss of granular carbofuran would have little immediate impact on rutabaga production; however, reliance on the two remaining organophosphorous insecticides could lead to future resistance problems.

5.1.3 All uses of granular carbofuran on corn, onions and carrots.

- The bulk of the risk information available was generated for corn. According to CWS, industry studies, monitoring efforts and the kill record indicate that this use pattern is a clear hazard, regardless of the exact planting method (i.e., whether granules are banded or applied in furrow). Proposed attempts at mitigation such as setbacks from field edges, improvements in existing planters and grower training have failed.

- No systematic data were generated on carrot or onion fields but the conjecture is that conditions are similar in these other crops.

- Loss of granular carbofuran would have minimal impact on onion production. Although registered, granular carbofuran is currently not marketed for use on carrots.

5.2 Registered Uses of Flowable Carbofuran (480F) and Associated Comments for Consideration of Regulatory Options:

Flowable carbofuran is registered for use on a variety of crops at differing rates of application. Both the risk to wildlife and the value to agriculture differ among these uses. Therefore, in considering regulatory options for flowable carbofuran, each use should be considered separately. For the ease of presentation, the registered uses of flowable carbofuran are listed as general use groups on the basis of the use pattern, the risk to wildlife and the value to agriculture. However, this does not necessarily mean that the chosen regulatory options have to be the same for each crop within these groups.

5.2.1 All uses of flowable carbofuran on barley, canola, flax, headlands, mustard, oats, pastures, roadsides, sunflower, sweet clover and wheat.

- These uses represent the lowest registered rates of application of flowable carbofuran (i.e., 0.072-0.132 kg a.i./ha). Most of the uses are to control grasshoppers. The 0.072 kg a.i./ha rate is registered only for the control of flea beetles on canola and mustard.

- The primary concern is the risk to the Burrowing Owl. The 250-metre no-spray zone around Burrowing Owl nests, instituted in 1989, may not in itself be sufficient in affording adequate protection to the owls. Despite an aggressive awareness campaign conducted by CWS and the Canadian distributor, the level of knowledge among users of this use restriction is questionable.

- The risk to the Burrowing Owl could be reduced by identifying the range of the owl and prohibiting the use of flowable carbofuran within the identified area.

- The CWS considers applications for control of the orange blossom midge and the sunflower beetle to pose less risk to the Burrowing Owl than applications for grasshopper control.

- Data indicate that the impact on songbirds is considered to be low; however, the margin of safety, based on reduction in brain cholinesterase activity, is thought to be slight to non-existent.

- Impacts to small mammals and gulls have been documented. There may also be a concern with regard to secondary poisoning of raptors on the basis of measured residues in small mammals captured in treated fields.

- Carbofuran is highly effective for grasshopper control in these crops. If carbofuran were removed from the market, growers would replace carbofuran with more costly alternative insecticides. This could result in an increase in production costs for grasshopper control, especially in years of severe grasshopper infestations.

- Flowable carbofuran is highly effective for flea beetle control in canola. If this use were removed from the market, growers would replace carbofuran with more costly alternative insecticides which could result in an increase in production costs. This increase could be greater if granular carbofuran were not available.

5.2.2 All uses of flowable carbofuran on alfalfa.

- The registered rate of application is 0.132 to 0.264 kg a.i./ha.

- Of primary concern is the risk to grazing waterfowl and small mammals, and secondary poisoning resulting from feeding on poisoned prey. Current data from studies conducted in U.S. alfalfa fields using higher rates of application and from the calculation of residues on treated crop suggest a risk to wildlife. Field data demonstrating these risks are lacking; however, risks to small mammals were shown at the lower rate in a treated pasture. The extent to which secondary poisoning occurs is not known.

- Large scale mortality of waterfowl have been recorded in U.S. alfalfa fields but under conditions different from those encountered in Canada (e.g., large wintering flocks of birds). Extrapolation to Canadian alfalfa fields cannot be made with the data currently available.

- Risk to wildlife could be limited by restricting use of the product to seed alfalfa. However, the extent to which feed alfalfa is sprayed is not known; therefore, the reduction in acreage of use cannot be determined.

- Prohibiting use of the product within range of the Burrowing Owl would reduce the risk to this species. While not specifically addressed in the risk assessment, the impact of carbofuran on pollinating bees (e.g., leafcutter bees) would have to be considered with this use.

- Flowable carbofuran is effective in terms of crop protection; however, there are registered alternatives.

- Registration, if maintained, could be contingent upon the registrant's supplying data regarding the impact of carbofuran use on wildlife in alfalfa at registered rates of application.

5.2.3 All uses of flowable carbofuran on corn (sweet, field, silage).

- The rate of application of flowable carbofuran to corn ranges from 0.132 to 0.528 kg a.i./ha depending upon the target pest. The principal use is for the control of European corn borer at the 0.528 kg. a.i./ha rate.

- The primary concern is the risk to songbirds in field edges. Field studies conducted at approximately the highest label rate (0.55 kg a.i./ha) in alfalfa indicate an impact to songbirds. However, field data demonstrating impact on songbirds at the lower rates (0.132-0.24 kg a.i./ha) are lacking. The data available suggest that flowable carbofuran applied to corn at the lowest label rate (0.132 kg a.i./ha) would have low impact on songbirds. Corn is grown largely outside the range of the Burrowing Owl, the main species of concern at the 0.132 kg a.i./ha rate.

- In theory, insecticide drift to field margins should be greater during application by air than by ground equipment. Therefore, risk to wildlife may be reduced by restricting application to ground equipment. However, according to CWS, existing company studies indicate that restriction to ground application alone did not satisfactorily reduce field edge contamination. A further possibility is to require the use of drift control equipment (e.g., spray skirts).

- The risk to wildlife could be further reduced by imposing a setback around field edges. However, the practicality of this option in terms of implementation and enforcement is not known.

- Flowable carbofuran is effective against the target pests. There are registered alternatives for control of these pests. However, loss of carbofuran for control of European corn borer could require growers to switch to less effective or more costly alternatives.

- Registration, if maintained, could be contingent upon the registrant's supplying data regarding the impact of carbofuran use on wildlife in corn fields when applied at the lower rates of application (i.e., 0.132-0.24 kg a.i./ha), or data on the success of the mitigation measures suggested for the high rate of application (i.e., 0.528 kg a.i./ha).

5.2.4 All uses of flowable carbofuran on green peppers and potatoes.

- The registered rate of application of flowable carbofuran to green peppers and potatoes ranges from 0.264 to 0.816 kg a.i./ha. The highest rate of application is recommended only for treatment of high aphid populations.

- Field data are lacking for the impact of flowable carbofuran on wildlife in these crops; however, risk is presumed based on the high rates of application. Of primary concern, is the risk to wildlife in field edges.

- Risk to wildlife could be mitigated in a manner analogous to that described earlier for corn (e.g., through control of drift to field edges).

- With regard to the potato uses, prohibition against use in heavy soil prone to flooding or puddling would limit the impacts to wildlife.

- Flowable carbofuran is effective against the target pests, however, there are registered alternatives, especially for aphid control.

- Loss of carbofuran for use on peppers could make corn borer control more difficult. If carbofuran were removed from the market, pepper growers would have to apply alternative insecticides which could lead to increased production costs and possibly more rapid development of resistance to the registered alternatives.

- Loss of carbofuran for control of Colorado potato beetle on these crops would have little impact on production in areas where resistance to this insecticide has been reported.

- Registration, if maintained, could be contingent upon the registrant's supplying data to allow for an assessment of the impact of this use on wildlife.

5.2.5 All uses of flowable carbofuran on raspberries and strawberries.

- The rates of application of flowable carbofuran to raspberries and strawberries range from 0.528 to 1.2 kg a.i./ha.

- Field data are lacking for the impact of flowable carbofuran on wildlife in these crops; however, risk is presumed based on the high rates of application. Of primary concern is the risk to wildlife in field edges. The post-harvest use is also of concern because wildlife may enter the fields at this time to feed on discarded or unharvested fruit.

- Risk to wildlife could be reduced by imposing additional limitations on the use of the product (e.g., application by ground application only; imposing a setback around field edges; prohibiting use in areas prone to puddling).

- Flowable carbofuran is highly effective against the target pests. Effective registered alternatives are none or few, depending upon the pest and region.

- Registration, if maintained, could be contingent upon the registrant's supplying data to allow for an assessment of the impact of this use on wildlife.

5.2.6 All uses of flowable carbofuran on sugar beets.

- The rate of application of flowable carbofuran to sugar beets is 1.12 kg a.i./ha.

- Field data are lacking for the impact of flowable carbofuran on wildlife in this crop; however, risk is presumed based on the high rate of application. Of concern is the risk to wildlife from field puddling following application, especially because post-spray irrigation is suggested.

- Flowable carbofuran is effective against the target pests; however, there are registered alternatives.

- Registration, if maintained, could be contingent upon the registrant's supplying data to allow for an assessment of the impact of this use on wildlife.

5.2.7 All uses of flowable carbofuran on turnips and rutabagas.

- These uses represent the highest registered rates of application for flowable carbofuran (2.52 kg a.i./ha).

- The soils where turnips and rutabagas are grown are often prone to puddling. Kills of birds have been documented in turnip and rutabaga fields following treatment with flowable carbofuran.

- If carbofuran were removed from the market, turnip and rutabaga growers would use registered alternatives for root maggot control. The increased use of these alternative insecticides could lead to the development of future resistance problems.

6.0 Regulatory Management Process

Agriculture Canada uses an established regulatory management process in making significant or complex registration decisions on pesticides. This approach involves consideration of both the scientific and public policy aspects of the risks and values associated with pesticide use. The risks and values of carbofuran use in agriculture can be measured and assessed by specialists. In a public policy context, the risks and values also warrant comment from other interested and affected parties, including the users of carbofuran, the agri-food industry, public interest groups and the general public.

Therefore, Agriculture Canada, in keeping with recognized decision-making procedures, is undertaking public consultation by means of this Discussion Document. Responses to this Discussion Document will be considered in making a regulatory decision regarding the future use of carbofuran in agriculture. Interested and affected parties are invited to send their comments, in writing (2 copies), to the Plant Industry Directorate of Agriculture Canada. Please address correspondence to:

Carbofuran Special Review
Plant Industry Directorate
Agriculture Canada
Ottawa, Ontario
K1A OC5

Appendix I

Registered Uses of Carbofuran:

Note: all rates are expressed in terms of active ingredient (a.i.)

Alfalfa:

Pests: alfalfa weevil, alfalfa blotch leafminer

Formulation: 480F
Rate (of a.i.): 0.264 kg/ha.
Aircraft or Ground Application: Apply when 25 percent of the alfalfa tips show feeding damage. If the period before harvest is less than seven days, spray stubble after harvest. For ground application, do not use less than 100 L of water per hectare; if applied by air, do not use less than 50 L of water per hectare. Consult Ontario Field Crop Recommendations (Publ. 296) for the use of lower rate in Ontario.
Limitations: (1) (3) (4) (5) (7) (9) (10) (11) (12)

Alfalfa, Barley, Canola (Rapeseed), Flax, Headlands, Mustard, Oats Pastures, Roadsides, Sweet Clover, Wheat:

Pests: grasshoppers

Formulation: 480F
Rate (of a.i.): 0.132 kg/ha.
Aircraft or Ground Application: Apply when grasshoppers are present. Apply in sufficient water for good coverage. Furadan may be tank-mixed with phenoxy ester or amine herbicides, and should be used only on crops listed on both labels. Follow directions on herbicide label with respect to rates of application of the herbicide and timing of spray. Application by aircraft is permitted.
Limitations: (1) (3) (4) (5) (6) (7) (9) (10) (11) (12)

Carrots: (Note: carbofuran is registered for use on carrots but is not currently marketed for that use)

Pests: carrot rust fly (first generation only), six-spotted leafhopper

Formulation: 10G
Rate (of a.i.): 2.25 kg/ha.
Apply in the seed furrow at the time of planting. Supplemental sprays with another insecticide are necessary, particularly where insects can be numerous. Consult local extension specialist for information on these sprays.
Limitations: (8) (10) (11)

Corn (Field, Sweet, Silage):

Pests: northern corn rootworm, western corn rootworm

Formulation: 10G
Rate (of a.i.): 1.1 kg/ha (using 100 cm row spacing), or 11 g/100 m row.
At time of planting, apply an 18-cm band on the soil surface behind the planter shoe. Incorporate lightly into the soil by dragchain or similar means.
Harvested crops may be fed to livestock.
Limitations: (1) (8) (10) (11)

Formulation: 480F
Rate (of a.i.): 0.24 kg/ha
Apply in sufficient water for good coverage. Spray when adult rootworms are feeding on silks prior to corn pollination. Pollination may be reduced by insect feeding from silk emergence through until silks begin to dry. A repeat application may be needed if reinfestation occurs. Consult local extension specialists for threshold levels. Cobs, husks and stalks may be fed to livestock.
Limitations: (1) (3) (4) (5) (7) (9) (10) (11) (12)

Pests: European corn borer

Formulation: 480F
Rate (of a.i): 0.528 kg/ha.
Apply in sufficient water for good coverage. Spray not later than when first feeding is seen on foliage. For second brood borers in late plantings, apply before tassels show. Consult local spray schedule for number and timing of applications. Cobs, husks and stalks may be fed to livestock.
Limitations: (1) (3) (4) (5) (7) (9) (10) (11) (12)

Corn (Field Sweet):

Pests: grasshoppers

Formulation: 480F
Rate (of a.i.): 0.132 kg/ha.
Apply in sufficient water for good coverage. Apply when grasshoppers are present. Furadan may be tank-mixed with phenoxy ester or amine herbicides, and should be used only on crops listed on both labels. Follow directions on herbicide label with respect to rates of application of the herbicide and timing of spray. Do not apply more than twice per season. Application by aircraft is permitted.
Limitations: (1) (3) (4) (5) (7) (9) (10) (11) (12)

Mustard, Canola (Rapeseed):

Pests: flea beetles

Formulation: 5G, CR-10
Rate (of a.i.): 0.225-0.280 kg/ha.
Seeder Application: Apply a mixture of Furadan granules and seed preferably with a hoe or press drill. Do not use disc-type seeding equipment. Harrowing after seeding causes loss of efficacy. Use the higher rate for heavy infestations.
Limitations: (1) (10) (11)

Formulation: 480F
Rate (of a.i.): 0.072-0.132 kg/ha.
Apply about two weeks after seeding or when insects are first noticed. Use not less than 100 L of water per hectare.
Limitations: (1) (3) (4) (5) (7) (9) (10) (11) (12)

Pests: red turnip beetle

Formulation: 480 Flowable.
Rate (of a.i.): 0.132 kg/ha.
Apply when insects are first noticed. Use not less than 100 L of water per hectare.
Limitations: (1) (3) (4) (5) (7) (9) (10) (11) (12)

Onion (Dry, From Seed):

Pests: onion maggot

Formulation: 10G
Rate (of a.i.): 1.75 kg/ha with 40-cm row spacing.
Apply with the seed in the furrow at planting time. Use only with onion seed treated with a registered fungicide for smut control. Do not use on pickling or green bunching onions or on onions grown from sets.
Limitations: (1) (8) (10) (11)

Pepper (Green):

Pests: European corn borer

Formulation: 480F
Rate (of a.i.): 0.528 kg in 1000-1250 L of water/ha.
Ontario: Apply when the second generation has hatched, usually in early August. Repeat at intervals of seven days.
Limitations: (1) (3) (5) (7) (9) (10) (11) (12)

Potato:

Pests: aphids, Colorado potato beetle, potato flea beetle, potato leafhopper, tarnished plant bug

Formulation: 480F
Rate (of a.i.): 0.264-0.816 kg in 800-1000 L/ha.
Apply when insects are first noticed, and repeat as necessary. Spray at a minimum pressure of 875 kPa. Use the high rate for heavy infestations of aphids. If Colorado potato beetle is the only insect to be controlled, reduce rate to 0.264 kg/ha. For potato flea beetle in the Maritimes only, use 0.264 kg/ha.
Limitations: (1) (3) (7) (9) (10) (11) (12)

Pests: Colorado potato beetle, potato flea beetle, potato leafhoppers

Formulation: 10G
Rate (of a.i.): 3.25 kg/ha (using 90-cm row spacing), or 30.0 g/100 m row.
Band Treatment: Apply at the time of planting either in a 10-cm band in the seed furrow, or drilled into the soil 10 cm on each side of the row and 5 cm below the seed. Inspect crop regularly for insects. Spray with Furadan 480 Flowable when needed.
Limitations: (1) (8) (10) (11)

Pests: wireworm

(Note: carbofuran is registered for control of wireworms on potatoes but is not currently marketed in Canada for this use)

Formulation: 5G, 10G
Rate (of a.i.): 3.25 - 5.5 kg/ha
In Atlantic provinces, apply as a broadcast treatment (using 5.5 kg/ha rate) before planting over the entire field and disk into the soil to a depth of 12-15 cm.
In eastern Canada and British Columbia, apply as a band treatment (using 3.35 kg/ha rate) at time of planting by drilling into soil on both sides of row with Gandy applicator; bands should be 25 cm apart and 5 cm below the seed. Product may also be applied as a 10 cm band into seed furrow.
Limitations: (1) (8) (10) (11)

Raspberry:

Pests: bud or root weevil

Formulation: 480F
Rate (of a.i.): 0.528-1.2 kg in 100 L/ha.
British Columbia Only: Apply once when buds are damaged to the lower 50 cm of canes and soil, before May 7. Make one application after harvest if necessary.
Limitations: (1) (3) (7) (9) (10) (11) (12)

Strawberry:

Pests: spittlebug, root weevil

Formulation: 480F
Rate (of a.i.): 0.528-1.2 kg in 1000 L of water per hectare.
British Columbia Only: Apply only if fresh leaf notches caused by adult weevils are seen in April. Spray before the end of the first week of May (before blossoming) and repeat immediately after harvest if more fresh notches appear. Make further post-harvest applications only if fresh notches are seen between July and October. The spring treatment also controls spittlebug. Do not apply between blossoming and harvest.
Limitations: (1) (3) (7) (9) (10) (11) (12)

Pests: strawberry weevil (blossom clipper), tarnished plant bug

Formulation: 480F
Rate (of a.i.): 0.528 kg/ha.
Eastern Canada Only: Make one application just before the first blossoms open. Use sufficient water for good coverage. Do not apply later than first bloom.
Limitations: (1) (3) (7) (9) (10) (11) (12)

Sugar Beet:

Pests: sugar beet root maggot

Formulation: 10G
Rate (of a.i.): 0.85 kg/ha.
Apply directly into the seed furrow at the same depth as the seed or slightly above the seed. Do not apply starter fertilizer in the same furrow. Tops and pulp from treated sugar beets may be fed to livestock.
Limitations: (1) (8) (10) (11)

Formulation: 480F
Rate (of a.i.): 1.12 kg in 200 L of water per hectare.
Apply as a soil drench over the row at the very early stage of root maggot activity, usually the first week of June. Application must be followed by a light sprinkler irrigation to incorporate Furadan into the soil.
Limitations: (1) (3) (5) (7) (9) (10) (11) (12)

Sunflower:

Pests: grasshoppers, sunflower beetle

Formulation: 480F
Rate (of a.i.): 0.132 kg/ha.
Apply when insects are first noticed. Do not use less than 100 L of water per hectare. Do not spray after plants are more than 60 cm in height or after heads have started to form. For sunflower beetle, application by aircraft is not effective.
Limitations: (1) (3) (5) (7) (9) (10) (11) (12)

Turnip, Rutabaga:

Pests: flea beetles, root maggots

Formulation: 480F
Rate (of a.i.): 0.180 kg in 100 L of water per 1000 m of row, or 2.52 kg in 1300 L of water per hectare with 70 cm row spacing.
Apply after seeding but before emergence. Apply as a coarse spray in a 10-cm band over the row. In eastern Canada, make two additional applications, one five weeks after seeding and another five weeks later (mid-August). In the prairie provinces, make two additional applications, one in early July and another in early August. In British Columbia, make additional applications 30, 50, and 70 days after seeding.
Limitations: (1) (2) (3) (7) (9) (10) (11) (12)

Pests: root maggots

Formulation: 10G
Rate (of a.i.): 17.5 g/100 m row, or 2.5 kg/ha (with 70 cm row spacing).
At the time of seeding, apply a 10-cm band on the soil surface in front of the planter shoe and incorporate into the soil while seeding. Opening and closing the furrow gives the incorporation. Further treatment - spray FURADAN 480 Flowable as directed on that label.
Limitations: (1) (2) (8) (10) (11)

Formulation: 5G (registered for control of root maggots on turnips and rutabagas but not currently marketed for this use).
Rate (of a.i.): 17.5 to 25 g/100 m of row.
Atlantic provinces: use a subsurface insecticide applicator and apply the 25 g rate as a 10-cm band 2.5 cm below the soil surface. Close furrow and plant seed 1.25 cm deep above the centre of the band. For treatment of small areas, apply the 17.5 g rate as a 10 cm band while seeding, incorporating into the soil to the same depth as seeding.
Other provinces: Apply 17.5 g rate as a 10-cm band on the soil surface just before opening the furrow for seeding, and incorporate into the soil. Place the spout for applying the product in front of the shoe which opens the furrow. Opening and closing the furrow provides the incorporation.
Limitations: (1) (2) (10) (11)

Wheat:

Pests: orange wheat blossom midge

Formulation: 480F
Rate (of a.i.): 0.132 kg in 50 L of water per ha.
Apply spray when 25 percent of the wheat heads have emerged from the boot and preferably before flowering has begun. Application by aircraft is permitted.
Application should be in afternoon or evening when temperatures exceed 15°C and wind speed is less than 10 km/h.
Limitations: (1) (3) (4) (5) (7) (9) (10) (11) (12)

Limitations:

1. Do not apply to crops within the following preharvest intervals (days, except as otherwise specified):

Crop	PHI
alfalfa, 0.264 kg rate	7
alfalfa, 0.132 kg rate	1
barley	21
canola/rapeseed, granular formulation	apply at planting time only
canola/rapeseed, flowable formulation	60
corn, granular formulation	apply at planting time only
corn, flowable formulation	7
flax	21
green pepper	3
mustard, granular formulation	apply at planting time only
mustard, flowable formulation	21
oats	21
onion	do not apply after seeding
pastures	1
potato, granular formulation	apply at planting time only
potato, flowable formulation	7
raspberry	56
rutabaga, granular formulation	apply at planting time only
rutabaga, flowable formulation	40
strawberry	do not apply after first bloom
sweet clover	28
sugar beet, granular formulation	do not apply after seeding
sugar beet, flowable formulation	120
sunflower	60
turnip, granular formulation	apply at planting time only
turnip, flowable formulation	40
wheat	21

2. Do not feed treated foliage to livestock; mature roots may be fed to livestock.

3. Do not apply when crops are in bloom or allow spray to drift toward beehives.

4. Do not graze or feed to livestock within the following intervals (days) after application:

Crop	PHI
alfalfa, 0.132 kg rate	1
alfalfa, 0.264 kg rate	7
barley	21
corn, 0.132 kg rate	3
corn, 0.24-0.528 kg rate	7
canola/rapeseed	60
flax	21
oats	21
mustard	21
pastures	1
raspberry	28
sweet clover	28
wheat	21

5. Do not make more than the following number of applications per season:

Crop	PHI
alfalfa, 0.132 kg rate	2
alfalfa, 0.264 kg rate	1
barley	2
canola/rapeseed	1
corn, 0.132 kg rate	2
corn, 0.24-0.528 kg rate	4
flax	1
green pepper	6
headlands	2
mustard	1
oats	2
pastures	2
roadsides	2
sugar beet	1
sunflower	2
sweet clover	2
wheat	2

6. Do not permit livestock to graze on roadsides or headlands within 1 day after application.

7. NATURE OF RESTRICTION: This product is to be stored and displayed apart from food and feed.

8. Do not use in fields which are subject to flooding.

9. Special precautions for reducing exposure to the Burrowing Owl: Do not apply within 250 metres of Burrowing Owl nests.

10. Keep out of areas inhabited by fish, birds and wildlife.

11. Do not apply or allow spray to drift to areas occupied by unprotected humans or beneficial animals.

12. Remove cattle before spraying.