RANGE

Operational Field Guide

to the propagation and establishment of the bioagent
Larinus planus
(Canada thistle seed-feeding weevil)

May 2001

Province of
British Columbia
Ministry
of Forests

Information contained in this Field Guide is comprised of fact and field observations as of May 2001.
Site specific experiences may vary.
Compiled and edited by Susan Turner

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Forest Practices Branch
Range Section
Noxious Weed Control Program
British Columbia Ministry of Forests

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1. PURPOSE

This document summarizes information for the biocontrol agent *Larinus planus* while it was classified as 'primary' and the responsibility of the Forest Practices Branch. The information is a combination of hard facts and field observations. Intended as a 'field guide' for those unfamiliar with *L. planus*, a seed-feeder of Canada thistle (*Cirsium arvense*), the summary contains pertinent information for field propagation and establishment of the bioagent as well as a historical background of its introduction into British Columbia.

2. INTRODUCTION

The goal of the Ministry of Forests Weed Control Program is to reduce target weed populations to ecologically and economically acceptable levels and to prevent their encroachment into new areas. The biological control portion of the program includes biocontrol agent screening, propagation, release, collection and monitoring.

Implicit in the use of biocontrol methods is the acknowledgment that weed eradication is not a goal. Rather, bioagent species and host weed species exist in predator-prey relationships with the weeds held at acceptable population levels and the insect populations self-sustaining.

The biocontrol program is a cooperative venture between the Ministry of Forests (MOF), Ministry of Agriculture and Food (MAF), Agriculture and Agri-Food Canada (AAFC), Commonwealth Agricultural Bureaux International (CABI) in Switzerland, as well as numerous other provincial and state agencies across western North America.

"*Cirsium arvense* is one of the 80 most important weeds worldwide. It is indigenous to Eurasia, and is also present in the temperate zones of North and South America, Africa, New Zealand and Australia in the Southern Hemisphere. The plant grows under a wide range of conditions and is a serious weed on both cultivated and non cultivated land (CAB IIBC 1996)." Canada thistle is the most common thistle in New Zealand and one of the most serious weeds in North America. It was introduced into North America from Europe in the 17th century (Moore 1975). "Because of its seriousness and the range of habitats and lands invaded, control of *C. arvense* requires a multi-approach strategy. Control of Canada thistle includes tillage, mowing, herbicide application, competitive crops/plants, and biological control" (CABI 1996).

There are both introduced and adventive biological control agents for Canada thistle in North America. By 1984, several insects had been introduced into Canada but only the stem-boring weevil *Ceutorhynchus litura* and the stem-galling fly *Urophora cardui* had become established. Conversely, the seed-feeding weevil *Larinus planus*, the seed-feeding fly *Orellia ruficauda* and midge *Dasyneura gibsoni* Felt. arrived in Canada adventively (McClay 1989). Arrival of *L. planus* occurred after the flies yet it should be a more effective biological control agent. *O. ruficauda* has been documented to occur in 20

to 85% of the seedheads in a Canada thistle infestation and within these, 20 to 80% of the seeds are damaged. The variation occurs within geographic location and sampling date (Forsyth and Watson 1985). *L. planus* is expected to be more effective since a single larva can "destroy most or all of the seeds in a head" (McClay 1989). A large population of *L. planus* could therefore have quite an impact on the seed produced in a Canada thistle infestation. Although this weevil may not have an immediate visual effect on a Canada thistle infestation since it is a perennial with a creeping root system, it may slow the rate of re-infestation by decreasing spread of this weed by its windblown seed.

3. *LARINUS PLANUS*

Coleoptera: Curculionidae
Common name: Canada thistle seed-feeding weevil

BIOLOGY

GENERATIONS PER YEAR: one

ADULT STAGE: Adults are dark brown weevils 5-10 mm long. Following overwintering, the weevils emerge from the leaf litter around the Canada thistle plants (Powell et al 1994). During lab tests, adults began feeding within a couple days following emergence. Within two weeks of commencing feeding, at 22^{o}C, mating begins (McClay 1989). This corresponds with Canada thistle budding about mid June (Powell et al 1994). Oviposition takes place after 14-26 days. The female chews a hole into an unopened flower bud, usually in the lower half of the bud and deposits a single egg. The size of available buds is important to the weevil. The buds first become acceptable when they reach about 4.5 mm in diameter but lose their usefulness beyond 7 mm. The maximum rate of oviposition occurs on buds about 6 mm in diameter. ("In *C. arvense* the larva destroys the basal part of the pappus during its feeding. This leaves the tips of the pappus hairs as a loose bunch through which the adult can easily escape." (McClay 1989)). When larger buds (as found with a couple other *Cirsium* species) are selected (when preferred bud sizes are not available), some oviposition and development can occur. ("In the larger heads of *C. undulatum* and *C. flodmanii*, more of the pappus is left intact and the remaining tightly packed hairs do not provide an escape route for the adults." (McClay 1989).) After oviposition, the female then covers the hole with fecal material, creating a readily distinguishable oviposition mark. The egg hatches within four days of oviposition (McClay 1989).

PHOTO 1: ***Larinus planus*** **(adult)**

LARVAL STAGE: If more than one larva is deposited into a single flower bud, only one will survive. "The larvae feed on the developing tissues of the receptacle, achenes and the basal part of the pappus. Infested buds often fail to open fully and become somewhat distorted" (McClay 1989). Since the male thistles (see appendix A) have receptacles, basal portions of the pappus and "vestigial" ovaries (Moore 1975), it may be that the larvae can develop on both male and female thistles. The literature is unclear on this fact.

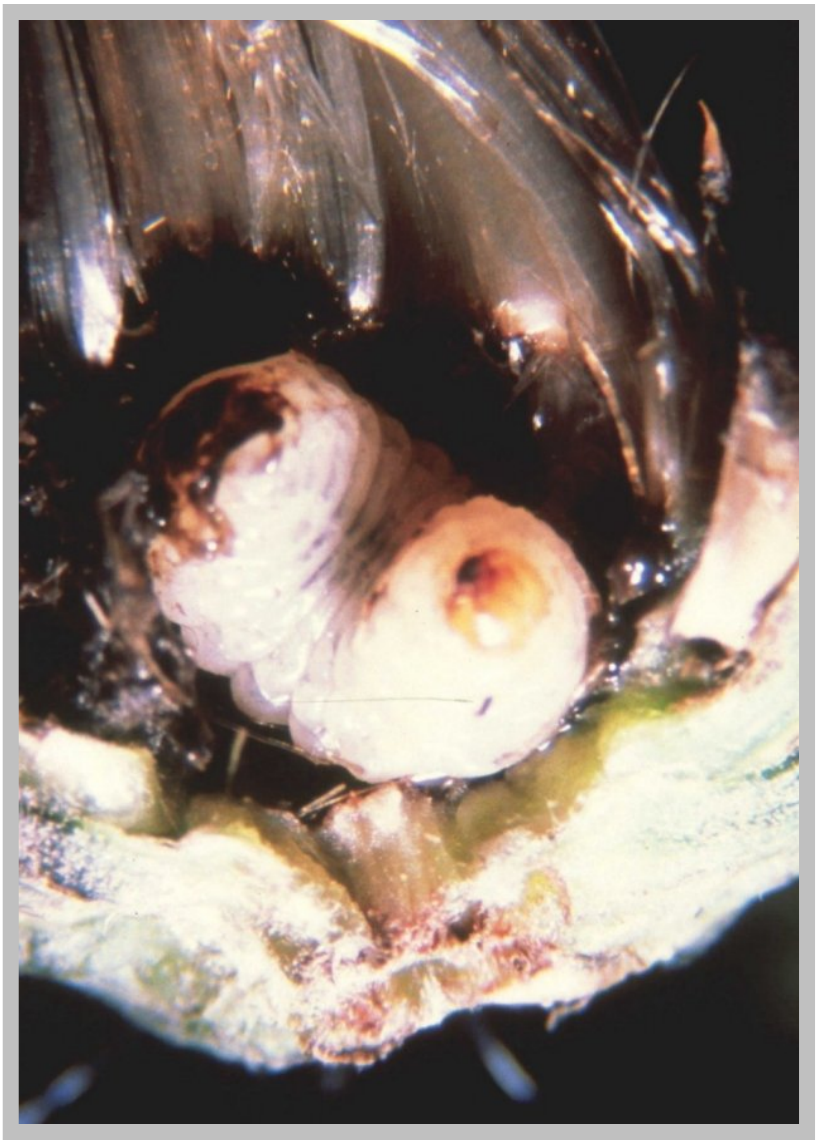

PHOTO 2: *Larinus planus* larva in seedhead in Peace River

PUPAL STAGE: "Pupation occurs in the bud inside a loose cocoon of chewed bud tissue" (McClay 1989).

F1 ADULTS: The development to adulthood takes approximately 36 days. Weevils emerge "through the loose pappus hairs at the apex of the bud. Newly emerged adults feed extensively, making rounded feeding holes mainly on the younger foliage" (McClay 1989). F1 adults overwinter before mating.

DISPERSAL METHOD: The adult weevil both walks and flies to reach its mate and host plants.

RANGE

Native (European) Distribution

L. planus occurs in southwest England and "throughout Europe except for central and northern Scandinavia, in North Africa (Morocco), Asia Minor, the Caucasis, and Central Asia (western Kazakhstan and Turkmenia)" (McClay 1989).

Adventive North American Distribution

L. planus is believed to be able to spread over most of Canada thistle's North American range (Figure 1).

L. planus has shown up in the northeastern United States in Pennsylvania, Maryland, New York and Ohio. In Canada, *L. planus* first revealed its presence on the campus of Simon Fraser University (SFU) in Burnaby, BC, in 1988 (McClay 1989).

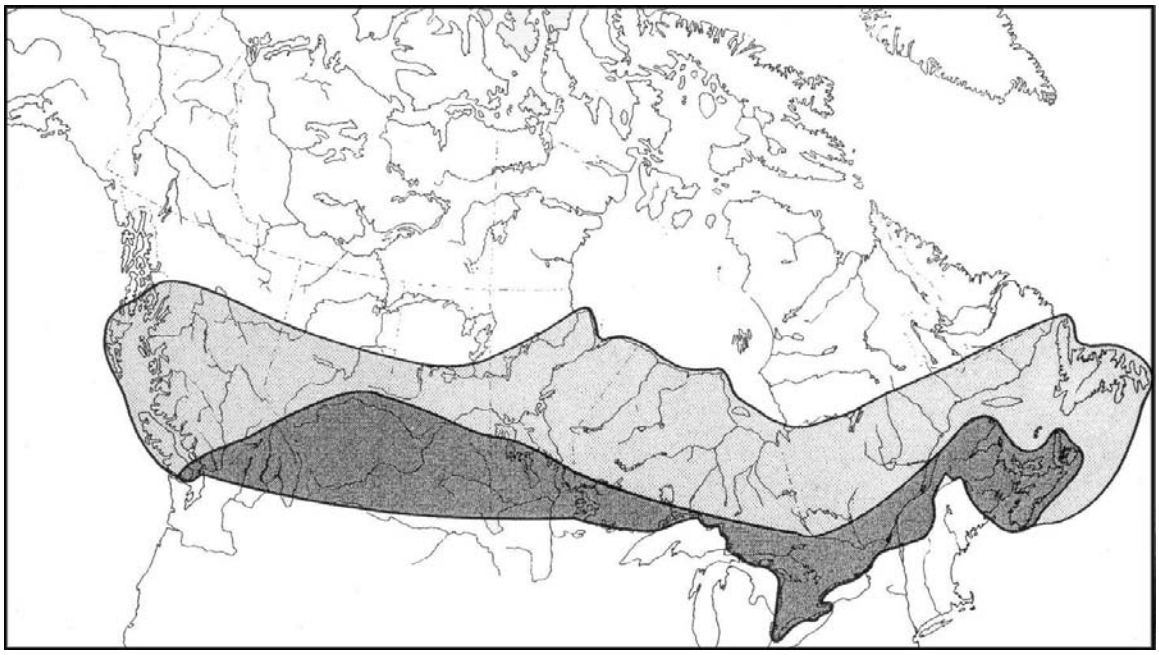

Figure 1: Canada Thistle in North America (Moore 1975)

HABITAT

L. Planus is thought to "survive in most parts of Canada" (Biocontrol News 1993). *L. Planus* appears to be well adapted to its host Canada thistle that spreads to new areas by wind-borne seed. Canada thistle is adaptable to a variety of habitat conditions. Generally, in the southern portion of the province, the weed is found in the Engleman-Spruce-Subalpine Fir (ESSF), Montain Spruce (MS), Coastal Western Hemlock (CWH), Interior Cedar Hemlock (ICH) and Interior Douglas-fir (IDF) zones and in moist microhabitats of the Bunchgrass and Ponderosa Pine biogeoclimatic zones. In the mid to northern portion of the province, Canada thistle is found again in the Coastal Western

Hemlock (CWH) and Interior Cedar Hemlock (ICH), and also in the Mountain Hemlock (MH), Interior Cedar Hemlock (ICH), Sub-Boreal Spruce (SBS), and Boreal White (BW) and Black Spruce (BS) zones.

In BC, *L. planus* has been released in the CWH, MH, BWBS, ICH, IDF and the BG zones. From Agriculture and Agri-Food Canada reports in 1992, the weevil was reported to have established in the BWBS zone in the Peace River (Harris pers comm 1992). Surveys of Canada thistle's growing habit in the Peace River show the buds to be larger than on most plants found in the rest of the province (Photo 3). Considering the discussion in the biology section concerning bud size, these large buds may not be ideal for *L. planus* development. It was also found in 1997 to have established in the ICHmk03 zone in the Robson Valley District. Monitoring in the Prince Rupert Region has to date shown negative establishment. A possible exception is a single release in 1993 that was successful only in the first year following the release but no weevils have been found since. In the southern regions, *L. planus* has established in the ICH, IDF and the BG zones and has spread well on its own throughout these zones as well as the PP zone. However, when the weevils were monitored in the Lillooet District, *L. planus* was found not to exist in the ESSF or MS zones.

Photo 3: Large Canada thistle flower heads in Peace River

L. planus has been observed in field sites to build to larger numbers, at least initially, in the drier range of Canada thistle. Observations reveal the weevil to congregate in higher numbers on plants growing in coarse soils rather than on those adjacent plants growing in moist, fine textured soils. Some moist sites observed over years, like Armour Creek

(Photo 4) in the Kamloops District, show *L. planus* populations increasing slowly, appearing to indicate that the weevil can adapt to moist conditions over time. If the site is too moist, such as having conditions of spring flooding, pooling water or high water tables, the weevils may drown while they overwinter in the leaf litter and soil at the base of the Canada thistle plants. Frequent irrigation as found in hayfields, pastures or orchards, can also discourage establishment of *L. planus*.

PHOTO 4: Armour Creek Site

L. planus has established well on all slopes. For example, a site in Wallachin in the Kamloops District resides on an extremely steep cut bank upon which the weevils have congregated and are thriving. This is probably due to preferential well-drained soils on the cut bank. *L. planus* was also found to have dispersed to sites with all aspects.

Although not monitored closely until recently, *L. planus* has been observed both in the Kamloops and Nelson Regions to disperse to new infestations rather than significantly congregate at single sites. Their numbers, therefore, generally appear not to increase a great deal at a single site. This makes collection more time consuming since often several sites must be visited to attain large numbers. There are exceptions to this, for example, as found at the Bachelor water reservoir shown in Photo 5. This BG site is very dry and Canada thistle is not normally found in this area. However, run off from rain fall hitting the dome is concentrated around the water tower, creating a slightly moister microclimate where the thistle is able to survive. There is also no shade other than that created by the dome and the plants themselves. *L. planus* flourish here, which supports other observations that although these weevils adapt to a large range of habitats, they do very

well in the hot/warm, drier range of Canada thistle. Their numbers also increase at this site, likely due to a lack of Canada thistle plants in the area that they are able to migrate to.

In the Kamloops Region, *L. planus* has been released in Kamloops, Salmon Arm and Vernon Districts only. However, it has been found in all districts to varying degrees of establishment with the exception of Lillooet. The weevil was found about 20 km east of the Lillooet border but no evidence of it was found within the boundaries of this district. To date, no releases have been made in the Lillooet District. Clearwater has had minimal establishment. Salmon Arm and Vernon have the weevil scattered widely throughout. Penticton was not thoroughly monitored, but at the canal between Okanagan Lake and Skaha Lake the adult weevils were found. Merritt District was checked only in a few locations but the presence was observed in the larval form. Much of the climate in Penticton and Merritt compliment the *L. planus* habitat requirements and would likely widely support the weevil's establishment. For more detailed monitoring information on releases in the Kamloops Region, see Appendix B.

The earliest Kamloops Region release was made in 1991 at the Bachelor water reservoir in Kamloops. This original release was made with only 45 adults and has since provided a few releases. Since 1991, only 21 releases of varying quantities have been made. From these few releases the weevil has dispersed freely. It is possible that the southern dispersal sites may have obtained their populations from migrates from the Nelson or Vancouver Forest Regions.

In the Nelson Region, the earliest release was made in 1989 with 100 weevils in Creston. Between 1991 and 1998, nine more releases were made in this Region. To date, *L. planus* is found throughout the Creston valley from the US border to north along Kootenay Lake. At the north end of Kootenay Lake, the weevils have survived and populations are increasing. *L. planus* has also spread from Balfour to Nelson and along the Kootenay River valley to Taghum, as well as from Nelson to south of Salmo. Along the Arrow Lakes, the 1995 IDF release has spread over 10 km south from Deer Park (Photo 6). To date there are no releases in the Boundary District, but, in 2000 the first releases were completed in the East Kootenay Districts.

PHOTO 5: Lac du Bois water reservoir site in 2000

PHOTO 6: Lower Arrow Lakes

4. HISTORY OF INTRODUCTION

The first report of *L. planus* in Canada is from SFU in Burnaby, BC, in 1988. An application to distribute the weevils was submitted in 1989. The first collection and release occurred in 1989 and every year thereafter up to and including 2000. Original collections in the first few years came from Burnaby and then from other sites established on the lower mainland. Field collections in the interior of BC have only begun in recent years. Collections and releases in BC have been nominal compared to other biocontrol agents to be designated as secondary in the Weed Control Program as *L. planus* tends to disperse well on its own.

SUMMARY OF COLLECTIONS AND RELEASES

The following tables summarize collection and redistribution data.

Collection and release summary of *Larinus planus* in B.C.[a]

	1989	1990	1991	1992	1993	1994
Collected	200	1050	445 + 3 releases	1125	1300	1000
Released	100	1050	445 + 3 releases	1125	1300	2000

	1995	1996	1997	1998	1999	2000
Collected	1300	600	200	400	840	3950
Released	1500	800	1200	700	840	3950

[a] *L. planus* weevils have been collected and distributed by both MOAF and MOF staff. The recording of numbers has not always been consistent between the two agencies.

Cariboo Forest Region

Field releases by district

Insects (# Releases)

DISTRICT	1994
Williams Lake	100 (1)
TOTAL	100(1)

Kamloops Forest Region

Field collections

Insects

SITE	1999	2000
Lac Du Bois	269	400
TOTAL	269	400

Field releases by district

Insects (# Releases)

DISTRICT	1991	1992	1993	1994[a]	1995
Clearwater					
Kamloops	45 (1)	500 (3)	600 (3)	200 (1)	300 (1)
Lillooet					
Merritt					
Penticton					
Salmon Arm					
Vernon			200(1)		100 (1)
TOTAL	45 (1)	500 (3)	800 (4)	200 (1)	400 (2)

DISTRICT	1996	1997	1999[a]	2000
Clearwater				
Kamloops	200 (1)	100 (1)	45 (1)	
Lillooet				
Merritt				
Penticton				
Salmon Arm	100 (1)	200 (2)		200 (1)
Vernon		400 (2)		
TOTAL	300 (1)	700 (5)	45 (1)	200 (1)

Nelson Forest Region

Field collections

Insects

SITE	2000
Creston	3,450
Salmo	100
TOTAL	3,550

Field releases by district

Insects (# Releases)

DISTRICT	1989	1991	1993	1994
Arrow		100 (1)		
Boundary				
Cranbrook				
Golden				
Invermere				
Kootenay Lake	100 (1)		200 (1)	100 (1)
Revelstoke				
TOTAL	100 (1)	100 (1)	200 (1)	100 (1)

DISTRICT	1995	1997	1998	2000
Arrow	600 (2)			
Boundary				
Cranbrook				525 (2)
Golden				
Invermere				200 (1)
Kootenay Lake		300 (3)	300 (1)	
Revelstoke				
TOTAL	600 (2)	300 (3)	300 (1)	725 (3)

Prince George Forest Region

Field releases by district

Insects (# Releases)

DISTRICT	1990	1991	1992	1993
Dawson Creek	200 (2)			
Fort Nelson				
Fort St. James				
Fort St. John	200 (1)	(1)	325 (1)	
Mackenzie				
Prince George				
Robson Valley		(2)		100 (1)
Vanderhoof	200 (1)			
TOTAL	600 (4)	(3)	325 (1)	100 (1)

DISTRICT	1994	1996	2000
Dawson Creek			
Fort Nelson			
Fort St. James			
Fort St. John			
Mackenzie			
Prince George			1,225
Robson Valley	400 (2)	100 (1)	1,800
Vanderhoof		100 (1)	
TOTAL	400 (2)	200 (2)	3,025

Prince Rupert Forest Region

Field releases by district

Insects (# Releases)

DISTRICT	1990	1991	1992	1993	1994
Bulkley	100 (1)	300 (2)	150 (1)		
Kalum					
Kispiox			150 (1)	200 (1)	200 (1)
Lakes					
Morice	200 (1)				
North Coast					
TOTAL	300 (2)	300 (2)	300 (2)	200 (1)	200 (1)

DISTRICT	1995	1996	1997	1998	1999
Bulkley					
Kalum		100 (1)			
Kispiox			200 (1)		
Lakes	200 (1)			400 (2)	
Morice					571 (1)
North Coast					
TOTAL	200 (1)	100 (1)	200 (1)	400 (2)	571 (1)

Vancouver Forest Region

Field collections

Insects

DISTRICT	1989	1990	1991	1992	1993	1994	1995	1996
Chilliwack	200	1,050	445+	1,125	1,300	1,000	1,300	600

DISTRICT	1997	1998	1999
Chilliwack	200	400	571

Field releases by district

Insects (# Releases)

DISTRICT	1990	1994	1995	1996
Campbell River				
Chilliwack	150 (1)		300 (3)	200 (1)
Duncan (South Island)		100 (1)		
Mid-Coast				
Port McNeill				
Queen Charlotte Islands				
Squamish		200 (2)		
Sunshine Coast				
TOTAL	150 (1)	300 (3)	300 (3)	200 (1)

Other Release Destinations

Distribution numbers recorded in this table are weevils given to other provinces.

Field releases by province

Insects (# Releases)

LOCATION	1994	1999
Alberta – Ag Canada		224
Edmonton	200 (2)	
Manitoba	300 (3)	
New Brunswick	200 (2)	
TOTAL	700 (7)	224

5. REDISTRIBUTION

Redistribution of agents is a critical part of the biocontrol program. To assist with distribution and thereby increasing the speed which *L. planus* is expanding throughout its potential provincial range, personnel should be able to recollect from field releases and make releases into new sites

FIELD COLLECTION

What and where to collect

Field collection of *L. planus* involves aspirating, tipping stems over collection containers to collect falling weevils, visually locating adult weevils in a Canada thistle infestation and hand picking them from plants or sweeping weevils from the plants with nets and then aspirating them from the nets.

Collecting *L. planus* weevils with nets is possible but the thistle plants tear at the nets and will soon destroy them. Also, Canada thistle plants tend not to hold up well from the battery of sweeping with nets. It is also possible to hand-pick weevils from the plant. This is cumbersome while wearing gloves and it is uncomfortable when not wearing gloves because of the plants' spines. Both these, therefore, are not recommended collection methods.

PHOTO 7: Sweeping Canada thistle plants for *Larinus planus*

Weevils can be observed on the plants starting in early June, either on the stems, leaf axils and tips, or on lateral and terminal buds. Weather conditions have some effect on locating the weevils. As with other weevils, in cooler temperatures the weevils are found low on the plant. In warm temperatures the weevils are found higher on the plant.

The following are suggested Collection Site Criteria*:

- Sites of all sizes have potential for collection with this insect. A possible criteria may be sites between 0.25 ha (2,500m^2) and 1.0 ha (10,000m^2) in size. Small sites may produce high insects/plant proportions faster than larger sites, yet, consideration must be given to longevity of the site. The insects may feed heavily and deplete the plants before need of the collection site is complete. Conversely, insects may disperse widely over larger sites, therefore, increasing collection time to attain desired numbers.
- Canada thistle density of preferred collection sites ranges from 3 to 5 stems/$m^{2.}$ When the infestations become more dense it is difficult to collect from individual plants without knocking adjacent plants and causing the weevils to fall from view.
- Hot to warm sites in the drier range of Canada thistle.
- Soils should be well-drained with a lack of standing water.
- Sites receiving cold air drainage may be poor choices, especially if they are relatively flat, allowing cold air to pond.

- Preferably on Crown land with easy access within 100 km of regional or district offices.
- Sites should be easily traversed for collection.
- Adequate snow cover, especially where winter temperatures fall below –15^{o}C.
- Flat or relatively flat - gentle slopes.
- <10 plants/meter square
- Narrow, linear sites recommended for ease of access to individual plants for the collector.
- Free of continuous disturbance.

*These criteria also need to be kept in mind when establishing future collection sites (current release sites) to ensure a future population of *L. planus* in the field. See discussion under Field Release.

How to collect

L. planus are generally collected either by aspirating the weevils directly from the plants or tipping the stems over collection containers to collect falling weevils.

Aspirating weevils directly from the plant works well as seeds, plant parts and other insects can be left at the site and the weevils are not jeopardized by storing them with spiders and other predators. Tipping stems over collection containers and tapping the stems to catch falling weevils works best at sites where large numbers of weevils exist per plant. These, in turn, may be emptied onto a flat, solid surface for counting and to eliminate seeds and other insects. Tipping the plant over your hand; or plucking the weevil off the plant from below to avoid the weevil dropping to the ground is also used although these methods are more time consuming. Avoid pulling a clinging weevil off a plant. They need to be gently persuaded to avoid injury. Plants need to be approached slowly when using these methods. If the weevils notice movement, the plant is shaken, a shadow is cast over them, or they feel suction of the aspirator before it traps them, they drop, landing on lower leaves, where they may be found again, or on the ground where they lie motionless in the soil and are difficult to see due to their small size. What ever the method used, beginner collectors may find it easier to crouch down at the plant level as it takes experience to develop ‘an eye’ for the weevils on the plants. A site should produce a minimum of 100 weevils/person collecting within an hour to be considered worthwhile for collection.

The weevils are placed into containers with a mesh opening in the lid. Mesh screen on the storage lids is critical to allow ventilation and to prevent a build up of condensation that can drown the insects. Depending on care taken and experience, the collection container may be free of any contaminants, but, it is good practice to check it and clean it if necessary before placing weevils in the cooler or refrigerator. Canada thistle leaves are placed in the containers to provide feed and a place for the weevils to cling (it also helps avoid weevils crawling over each other, fighting and injuring one another). Do not use plant material that is too lush as it produces a lot of condensation inside the containers that may drown the insects. If too much condensation does occur, place paper towels in the base of the container. Do not include seed heads in the container so as to avoid seed

spread. Also, thistle heads often contain parasites that would attack the weevils (Powell et. al. 1994). Containers are kept cool and out of direct sunlight in a portable cooler with ice packs wrapped first in plastic bags and then in paper towels to absorb any condensation. Avoid contact between the containers and the wrapped ice packs as condensation still may occur. In the office, the numbers of weevils are confirmed. *L. planus* are not sexed for field purposes. If the weevils are to be kept for any length of time before releasing, they should be stored in quantities of 50 or less/container. Every two days the weevils must be transferred to clean containers and fresh Canada thistle leaves added. When shipped, quantities of 100/container are used.

When to collect

Time of Year

Collection occurs between early to mid-June to mid-July. This varies slightly with seasonal weather, occurring later with cooler conditions. The weevils emerge as the thistle flower buds swell but prior to bloom. Egg laying occurs when the buds are fully swollen. By the time the plants bloom, the adult weevils will be difficult to find and likely the females will have laid all their eggs. Collection should end prior to the completion of oviposition. This allows for viable females to be left at the site to continue the existing population. Additionally, this allows for establishment at the release sites. Eggs require time to hatch and pupae must develop in order for the F1 generation to emerge in late summer.

During the spring collection period, the females will begin to cling to the buds with their mouth parts when chewing holes in the buds in preparation for egg laying. These weevils may require teasing off the flower bud or more aspirating suction to remove them from the plant.

Spring collection is preferred over August/September. In June, the weevils congregate to breed and the females lay eggs into unopened flower buds. They are, therefore, easily found on the tops of the plants. In contrast, the F1 generation in late summer is involved in feeding and preparing to overwinter. These weevils do not congregate and are not found on any specific part of the plant. They are, therefore, more difficult to find.

PHOTO 8: *Larinus planus* on Canada thistle bud

Time of Day

Warm days, whether from direct sunlight or from bright overcast days, have been found to be better for collecting than cooler days. The weevils tend to reside high on the plant on flower buds, upper leaves and leaf axils in the heat and lower when temperatures are less. Early morning collections are, therefore, not preferred.

Rain drives the weevils lower on the plant. Following rain showers, it has been observed that the weevils remain low on the plants and are not easily seen for some time, even until the following day.

However, after time, the female weevils must move to the flower buds to lay their eggs and will be easily found.

Additional considerations

Individual Canada thistle patches can be relatively small (except in the Peace River (Photo 9)). It is recommended that per each collection day, the sites should only be covered once. Also, several collection sites may be needed to accomplish a desired number of releases.

PHOTO 9: Large Canada thistle infestation in Peace River

SHIPPING

Collected insects are shipped to new release sites in 1 litre bulk food containers. To ensure population establishment, releases of a minimum two containers (100 adults per container) are recommended, particularly when confidence is high that the weevils will survive at the chosen site. When uncertain, larger release numbers should be considered to allow for some mortality and acclimation, but only when *L. planus* has been released at more secure sites to satisfy program goals.

The containers must be well ventilated and contain sufficient Canada thistle to feed the weevils during transport. Containers are packaged into carefully sealed boxes to avoid insect escape during shipment. Cold packs are wrapped first in plastic bags to contain the majority of condensation and then in newspaper or paper towelling to prevent further condensation from building up inside the containers and damaging or drowning the insects. The ice packs are used to keep the insects cool and reduce their activity if they are travelling any distance. As well, leaves tend to produce less moisture in the containers when they are kept cool. Avoid contact between containers and the wrapped ice packs by using packaging material as condensation still may occur. The agents are shipped quickly via courier or bus to individuals who will release the weevils in their respective areas.

FIELD RELEASE

Potential release sites

A potential release site needs to meet certain criteria to ensure success and longevity. It must meet Ministry needs from a program and logistic standpoint i.e. travel distance, land tenure, accessibility. It must also be conducive to agent survival and establishment.

Below are suggested release site criteria and considerations. They are based on observations of past sites that have been successful.

Criteria

- Release sites should contain plants with bud diameters between 5 to 7 mm as described in section 3 on biology. The buds must still be unopened. Once the thistle has open flowers, they will be of no use to the females for oviposition and the effort and agents will be wasted.
- In areas with cold winter climates, release sites should be able to accumulate a snow pack to insulate adult weevils residing in the soil from very low temperatures**.**
- From current knowledge, all aspects are preferred.
- Release sites should be large enough and contain enough Canada thistle to support a viable insect population with potential for natural dispersal (minimum 0.10 ha or 1, 000m^2).
- Soils may be coarse to fine and uniformly textured, but preferably well-drained.
- Soils with higher water-holding capacities are not preferred by the weevils. For better success of establishing the weevils in a new area, release them onto well-drained soils that they can later migrate from onto moister soils as their food supply declines or population densities demand.
- Sites should not be shaded.
- Topographies of successful sites have varied. All have been able to accumulate heat units. A hot to warm climate is preferred.
- Sites destined for future collection should be linear, as found along roadsides. Wide patches are difficult to move within and motion causes the weevils to drop from the plants. A plant density of 2 to 5 plants/m^2 is easily collectable while dense patches cause adjacent plants to be knocked and the weevils to fall from view. (If roadsides are used, the majority of the infestation and the point of release should be out of the range of highways mowing vehicles as the weevils require seedheads.)

Considerations

- Releases at any elevation should be attempted. For example, the highest recorded elevation where establishment has been confirmed in the Nelson Region is 850 m.
- Sites receiving cold air drainage may be poor choices, especially if they are relatively flat, allowing cold air to pond.

- Highly disturbed sites, particularly from cattle trampling, are not preferred as plants and weevils preparing to overwinter in the soil may be crushed.

The following are suggested steps to take when making a site selection:

1. Plan release site locations prior to requesting agents. Release sites should be pre-selected the fall or spring prior to release of agents. This avoids 'drop and dash' releases and promotes overall weed management planning.
2. Determine tenure and stability of land management. Preferably a site will be located on Crown Land with MOF mandated as the steward and have a cooperative tenure holder. Other suitable locations may be land under the jurisdiction of other agencies with the goals of controlling weeds and establishing/maintaining working relationships. Release sites might be located in or close to relevant municipalities with the goal of future cost-effective collection sites. An example of a release site is a municipal water reservoir which is long term and where most activity, particularly herbicide spraying, is prohibited.
3. Make sure the site will not be disturbed after release. Crown control of the site is preferred with future management known. Discuss future development plans for the site wherever it is located.
4. Check previous release records and maps to ensure no prior release of the agent has been made at a potential site. An unofficial rule states that a distance of 1 km constitutes a separate release.
5. Monitor plants at potential site to ensure the agent is not already present through natural dispersal.
6. Check the immediate vicinity of the proposed release site for ant hills and wasp nests to minimize predation.
7. Mark selected release sites with a stake so that it may be relocated to monitor insect progress and weed population decline.

Insect release

Before any weevils can be released there is preparatory work that needs to be completed at the site. Make sure that all paperwork, photos, site maps, measurements, etc. are completed before opening any lids, otherwise people will be treading on insects.

In the past, each release consisted of approximately 100 adults transported in a bulk food container, yet 200 adults in one or two containers is recommended.

The following are suggested steps to take when making an insect release:

1. Mark the release site with a semi-permanent stake to assist relocation efforts for follow-up agent establishment and weed impact monitoring.
2. Fill out the 'Biological Control Release Record' (see Appendix D) that is shipped with the weevils **accurately** and **completely**. Information on the form is fundamental to further analysis of the program. One completed copy of the

Release Record is kept in the District office and one is returned to the MOF Regional office. The forms are then collated to create a provincial database.

3. Create accurate site maps complete with permanent tie points. This is essential for future monitoring of the release site.
4. Take photographs. They have proven to be a useful tool to both relocate the release site and to provide an ocular comparison of the site over time. A suggested method and form (EM-9) is outlined in the Habitat Monitoring Manual.
5. Gently release the weevils (once the paper work is completed) at one location by the stake. They will disperse themselves from this initial release point. It is more difficult for insects to propagate if they are spread over a large area.

Additional considerations

Initial releases for the season should be made in similar latitudes, further south or at lower elevations than collection sites to ensure temperatures are conducive to agent establishment. As northern or higher elevation release sites warm, they can receive insects. Once temperatures at these sites begin to drop, releases should be directed south or at lower elevations again to provide for the longest possible establishment season.

If more than one collection site is available, it is preferable to redistribute weevils into habitats similar to those they are acclimatized to.

If agent establishment at a release site is uncertain or the Canada thistle infestation is particularly large, re-release of agents may need to be considered. Before re-releasing at a site the region/district plan needs to be reviewed, i.e. can agents be spared for re-release at a site that may or may not be conducive to the agents' survival when they could be placed at a new site?

Avoid sites near anthills. Also, black aphids heavily attack some Canada thistle plants. In turn, the aphids attract ants. *L. planus* tend to avoid plants covered with ants which have been observed to also attack the weevils.

6. MONITORING

Monitoring of field sites can be carried out to determine:

1. whether the agent has established at the release site;
2. the density of agents per plant or area;
3. how far the agent has spread from the release point;
4. the agent’s preferred habitat and current range;
5. areas that are unsuitable to the agent;
6. any effects the agent has had on the weed population;
7. potential collection sites;
8. if collecting from the site has had any effects on plant or agent populations; and/or
9. agent life cycle information i.e. emergence dates, effects of weather.

Depending on the type of information being sought, the monitoring technique will vary. Reconnaissance methods can be used to assess parameters such as site suitability, presence or absence of agents, dates of emergence etc. A suggested monitoring form ('Release Site Monitoring Form') detailing information to collect at each site can be found in the Appendix E. This form is intended for: assessing some site characteristics that may lead to a better understanding of bioagent preferences; assessing changes in the weed infestation; and comparing sites with known insect establishment for purposes of designating collection sites. Many details listed on this form can be found on the original release form. Some will not change over time and need not be duplicated if the information is already recorded, while other details, particularly the plant's density and distribution may change.

A more rigorous method is needed for quantifiable information on insect and plant populations. It is suggested that this type of monitoring be planned at selected sites as dictated by the constraints of program planning, time and budget.

A suggested monitoring method is as follows:

1. Find the release stake or from the description on the release form, the closest position to the release stake. Mark a starting point.
2. With a timing device and a hand counter (if necessary) move in concentric circles or in straight, non-overlapping lines away from the starting point counting the number of weevils found for a pre-determined time. Twenty minutes with one person or ten minutes with two people is recommended.

It is important to keep in mind that when a monitoring method is used, it should be consistent for all sites of a particular insect in order to have comparable results.

AGENTS

Sites can be monitored for the presence of adults from early June to late July (coinciding with flower bud development but prior to bloom) and again in late August to early September for the F1 generation.

During June to early July, the weevils will be feeding, mating and the females will be ovipositing. Following their emergence in the spring, the weevils mainly feed. They can be found all over the plants at this time, creating chewing holes in the leaves. When they begin to mate, they tend to congregate on the top portions of the plants. The females then oviposit into unopened buds, optimally into buds 6 mm in diameter. It is at the mating and ovipositing stages that the weevils will be most visible. Monitoring can be performed by counting the number of adults seen over a given time, for example, 20 minutes. Once a time is chosen (as well as the number of people monitoring), it should be consistent between sites to allow for population comparisons. A counter may be useful to keep track of the weevils' numbers. When the plants begin to bloom, the weevils generally are spent and gone.

F1 adults can be monitored from late August to early September. The weevils will be more difficult to locate at this time since they are feeding in preparation for overwintering in the soil and do not congregate together and are found on any particular location on the plant.

Monitoring can be done between these two periods. One can check for the larvae in the seedheads. This will be easier if done in early to mid-August to allow for the larvae to increase in size and be visible to the naked eye. Often, occupied buds will appear brown and contain only one larva. These must be opened to verify the *L. planus* larva as some other insects have the same effect on the thistle buds (Photo 10).

PHOTO 10: *Larinus planus* larva in seedhead

PLANTS

A method needs to be developed for measuring responses of the host weed population. Useful parameters to monitor would be: height, density, biomass production, seed production, cover, and frequency.

Feeding damage of *L. planus* on Canada thistle leaves is found within the leaf surface, not from the edges as often found with caterpillar feeding. *L. planus* creates holes in the

leaves that are generally round and uniform. In response to the feeding, the plant 'dies back' from the hole, creating a thin brown ring around the chewed area.

When checking the affected brown buds described above, it is important to determine the species of the occupant within as several insects cause the same effect. For example, Lepidoptera larvae were observed inside the buds in the Salmon Arm District. Unlike *L. planus*, it is thought these insects exited the bud through individual, small pinholes found at the bases of the buds. When a *Lepidoptera* larva was found and removed from the bud, it was observed to hang from a silk-like thread as produced by *Agapeta zoegana* in knapweed roots. Often the affected buds were empty and a black substance was found within the outer shell.

Painted Lady (*Vanessa cardui*) is another Lepidoptera often found on Canada thistle. The activity of the painted lady larvae inhibits the bloom of Canada thistle flowers. The insect creates webbing on the thistle and consumes the buds, leaves and stem parts. Its tight webbing folds the upper leaves just below the bloom. The larvae feed on the green buds, which also inhibits bloom. Large amounts of black frass are also an indication of its presence.

Another insect that feeds in the seedhead of Canada thistle leaves small exit holes out of the top of seedheads as seen in Photo 11 near Seven Mile Dam. This insect has not been identified, yet, the exit evidence is very different from that seen with *L. planus* where there is very little left of the internal structure of the seedhead.

PHOTO 11: Unexplained exit holes from flower heads of Canada thistle

A dark rust (*Puccinia punctiformis*) has been seen to occur on many Canada thistle plants. Affected plants are randomly scattered in an infestation and can appear obviously weakened. The rust has been observed to almost completely cover some plants from basal leaves to bud. *P. punctiformis* is commonly found throughout BC.

PHOTO 12: Canada thistle plant covered in rust (*P. punctiformis*)

RESULTS

L. planus has dispersed widely from its release sites and appears to have a wide range or acceptable habitat types. To date, monitoring has found that *L. planus* can establish in the Boreal White and Black Spruce, Interior Cedar-Hemlock, Interior Douglas-fir, Ponderosa Pine and Bunchgrass biogeoclimatic zones. The weevil may well extend its distribution into other biogeoclimatic zones. It does not favour poorly-drained soils but further specific site parameters are more difficult to summarize and analyze. Some generalities have been noted previously.

APPENDICES

Appendix A - HOST WEED

Canada thistle (*Cirsium arvense*)

The plant

- A perennial, introduced from Europe in the 17th century (Photo 13). The thistle stands up to 1.2 m tall on a smooth (unwinged), green, glabrous stem. The alternate leaves have deep, irregular, spiny lobes and grow from 4 to 21 cm in length. The underside of the leaf has white hairs while the surface is dark green and shiny. It spreads by a horizontal creeping root system and by wind-blown seeds. Aerial shoots, developing into what appears to be individual plants above ground, can originate from either the main vertical root, which extends down to the water table, the horizontal roots or from root pieces as small as 8 mm in length. In Canada, the thistle blooms in late June to July and continues until September. The rose-purple, pink or even white flowers occur in clusters of small, nearly spineless, heads (Photo 14) (Powell et al 1994). Canada thistle is the only native or introduced thistle in the country that has separate male and female flowers (Photo 15). The flowers are insect pollinated and the sexes must be in close proximity (33 m for good results) for seed production to occur. Under optimal conditions, male flowers may produce some seed. Female flowers, however, are the main producers of seed. Seeds are spread by wind when it catches the pappus, but, also by different means when the pappus readily breaks off the seeds. Canada thistle is able to hybridize with select *Cirsium* species. A possible hybrid exists between a rare native of BC and Alberta, *C. hookerianum* and was reported to exist in BC (Moore 1975). Canada thistle is also known to hybridize with *C. palustre*, or marsh plume thistle, (Moore 1975) which was thought to be rare in Canada but has recently been increasing rapidly in BC's Prince George Forest Region.

Habitat

- Widespread throughout B.C. Infestations in the Peace River are more extensive and the plants larger and more robust than in the rest of the province (see Photo 9).

Growing conditions

- Occurs in open mesophytic areas. Generally, Canada thistle exists within the mean temperature range of –22°C to –7°C for January and 10°C to 20°C for July. The annual precipitation within its habitat ranges from 300 to 1000 mm. The plant requires long days but cannot withstand extreme high summer temperatures. It does not do well in shade. Canada thistle exists in all types of soil but does best in clay soils. It can grow in very dry areas but struggles in wet soils where its root development is shallow (Moore 1975). "Canada thistle is found in cultivated fields and pastures and along roadsides, and in waste places. It grows under a wide range of habitats and occurs in all biogeoclimatic zones" (Powell et al 1994).

PHOTO 13: Mature Canada thistle plant

PHOTO 14: Canada thistle flowers with nearly spineless heads

PHOTO 15: Male and female flowers of Canada thistle plant - Suskwa River site in Prince Rupert Region (ICHmc2)

Appendix B - KAMLOOPS REGION DISPERSAL MONITORING RESULTS OF *LARINUS PLANUS,* 1999 - 2000

The Kamloops Forest Region contains 21 releases of *L. planus* which were monitored over the 1999 and 2000 field seasons. The results are compiled in the table below.

Monitoring of *Larinus planus* in the Kamloops Forest Region

Site #	Description	BEC	Mon.	Est.	Comments
KAMLOOPS					
No number	Bachelor water tower	BGxh2	99-06-22 00-06-21	Yes	Collected 200 adults in 1999, and 400 in 2000. Very small site.
No number	Gorman Lake Rd., west of Barriere	IDFmw2	99-07-13 99-07-29 00-07-09	Yes	No est. found in 99 on the few plants. Found plants and *L. planus* 3 km up the road, which may or may not be the actual release.
3159-01-92 3159-__-93	Cache Creek, 2 releases	BGxh2	00-06-07	Yes	*L. planus* found at all the scattered patches along the highway.
No number	Cinnamon Ridge	BGxh2	99-06-23 00-06-26	Yes	Small, dense stands with many distant scattered patches nearby. Collectable area.
3159-01-96 3159-02-96	Long Lake, Lac Du Bois grasslands, 2 releases	BGxw	00-06-21	No	Very moist site, few plants, lots of bird activity. Does not fit release criteria recommendations. Access to site restricted.
3162-001-93 3163-001-93	Heffley Lake	IDFmw2 IDFdk2?	99-06-28 00-07-06	Yes	Confusing and conflicting release info (site #, RU) over the 2 yrs releasing. Not est. in 99 but est. in 00.
SALMON ARM					
No number	Salmon Arm, Wildlife Reserve	IDFmw2	00-06-08	Yes	Moist site, few agents in widely scattered populations.
3055-01-97	Larch Hills	ICHmw2	99-07-18	Yes	Est. in 99 and dispersed to over 1 km away.
3056-02-97	Bongard Creek, Hunter/Blurton FS Rd.	IDFmw1	99-07-18 00-07-27	Yes	Not est. in 99 but est. was found in 00. Small scattered population of plants. Poor release site.

Site #	Description	BEC	Mon.	Est.	Comments
VERNON					
3289-03-97 3289-04-97 3289-05-97	Swan Lake and Hwy 97 area	IDFxh1a	99-07-15	Yes	Long infestation readily accepted by *L. planus*. Subject to mowing. Exact release site not checked, private, checked nearby ROW.
3295-01-95	Mabel Lake Road	ICHmw2	99-07-15	Yes	Private property, many plants sprayed with 2-4D. Moist. Poor est.
No number	Shantz Road, Vernon	IDFxh1a IDFxha?	00-06-24	Yes	Exact release site not inspected on private property, est. nearby on roadside plants.
3295-06-97 3295-02-97	Mabel Lake Road, 2 releases	ICH/IDF	99-07-15	Yes	Roadside patches observed and sampled for est. Farming practices encourage C. thistle growth, poor weed management.

APPENDIX C: LITERATURE CITED

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APPENDIX D: BIOAGENT RELEASE FORM

BIOLOGICAL CONTROL RELEASE RECORD

SITE NUMBER: D __ __ /___ ___ ___ ___/___ ___/___ ___ ___

BIOAGENT: _____/_____ **WEED SPECIES: ___ ___ ___ ___ / ___ ___ ___**

SOURCE: _____ **STAGE:** ADULT PUPA LARVA EGG OTHER

COLLECTION: __ __ / __ __ / __ __ **RELEASE: __ __ / __ __ / __ __** **TIME: __ __ : __ __**
YY/MM/DD YY/MM/DD

#RELEASED _____ JURISDICTION _____ RELEASED BY: _____

DISTRICT: _____ **RANGE UNIT NAME: _____**

PRIVATE LAND Owner: _____ Phone: ( ) ___ ___ ___ - ___ ___ ___ ___

ADDRESS: _____

LOCATION:_____

_____

BCGS MAP: __ __ __ __ __ __ __ **UTM :** |__|__| |__|__|__|__|__|__| |__|__|__|__|__|__|__| _____
ZONE EASTING NORTHING DATUM

WEED DENSITY: <1 plant/m^2 2-5 plants/m^2 6-10 plant/m^2 >10 plant/m^2

SIZE OF INFESTATION: < 100 m^2 101-400 m^2 401-2500 m^2
2501-5000 m^2 5001-10000 m^2 >1 ha.

WEED DISTRIBUTION: Continuous Stand: Scattered Patches: Distribution Code (1-9):_____

SLOPE %: _____ **ASPECT ^{0} : _____** **ELEVATION m : _____** **BIOGEO UNIT: _ _ __ _/_ _ _**
zone/subzone /variant/site series

MONITORING for ESTABLISHMENT

Date Monitored y/m/d			
__ __ / __ __ / __ __	Yes	No	Photo
__ __ / __ __ / __ __	Yes	No	Photo

COMMENTS: _____
_____
_____
_____

SKETCH MAP (Indicate North)

APPENDIX E – BIOAGENT MONITORING FORMS

RELEASE SITE MONITORING

DATE: **AGENT:**

SITE NUMBER: **SITE NAME:**

MAP NO.:

WEED DENSITY:

<1 plant/m^2	____	2-5 plants/m^2	____
6-10 plants/m^2	____	>10 plants/m^2	____

SIZE OF INFESTATION:

<100m^2	____	100-400m^2	____
400-2500m^2	____	2500-5000m^2	____
5000-10000m^2	____	>1 ha	____

WEED DISTRIBUTION:

Continuous Stand____ Scattered Patches ____

ACCESS TO SITE:

Easy	____	Difficult	____

Describe if necessary.

SITE TOPOGRAPHY:

Flat	____	Bowl Shaped	____
Forest Openings	____	Close to River/Lake	____
Terraced ____		Hillside ____	
Other (describe)	____		

TRAVERSABILITY OF SITE:

Easy	____	Difficult	____

Describe if necessary.

SOIL DESCRIPTION:

Moss covered	____	Gravel	____
Clay	____	Silt	____
Compact	____	Loose	____
Sandy	____	Other (describe):	____

SLOPE (%): ____ ASPECT (^{o}): ____ ELEVATION (m): ____

BIOGEOCLIMATIC CLASSIFICATION: _____

DISTANCE FROM KAMLOOPS (km): ____

LAND OWNER:

RECOMMENDATION:

COMMENTS:

BIOCONTROL AGENT MONITORING FORM

SITE NUMBER:		DATE: (YR/M/D)	
AGENT:		LOCATION:	
RELEASE DATE:		TARGET PLANT:	

METERS	NORTH	SOUTH	EAST	WEST
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
MAX DIST.				

PERCENT ATTACK: _____

COMMENTS: _____