Office of the Chief Plant Protection Officer

Threat Specific Contingency Plan

Common Name

Turnip moth

Scientific name

Agrotis segetum Denis & Schiffermüller 1775

Drafted by

OCPPO

June 2011

1 Purpose of this contingency plan

This contingency plan provides background information on the pest biology and available control measures to assist with preparedness for an incursion of Turnip Moth (*Agrotis segetum).* It provides guidelines for steps to be undertaken and considered when developing a Response Plan to this pest. Any Response Plan developed using information in whole or in part from this Contingency Plan must follow procedures as set out in PLANTPLAN and be endorsed by the National Management Group prior to implementation.

2 Pest information/status

2.1 Pest details

Common names:	Turnip moth, black cutworm, common cutworm, cutworm, dark moth, dart moth, tobacco cutworm, Turnip dart moth
Scientific name:	*Agrotis segetum* Denis & Schiffermüller 1775
Synonyms:	*see list of Synonyms in the Turnip Moth Pest Risk Review (available from PHA website)*
Taxonomic Position:	Phylum: Arthropoda; Class: Insecta; Order: Lepidoptera; Superfamily: Noctuoidea; Family: Noctuidae; Subfamily: Noctuinae; Genus: *Agrotis* Species: *segetum* Denis & Schiffermüller

2.1.1 General information

In Australia, Turnip moth larvae would find no shortage of hosts from crops (e.g., canola, barley, oats, wheat, cotton), to many garden and important horticultural plants (e.g., brassica vegetables, tomato, lettuce, daisy) and environmental weeds (freesias, *Gladiolus*, deadly nightshade). *Agrotis segetum* is a polyphagous pest in its current distribution (plants from 25 families have been listed as hosts).

It is possible that the Turnip moth may be capable of adapting to native Australian plants, though a closely related species, *A. ipsilon,* has not adapted to native Australian plants, and has limited pest status (Farrow and McDonald 1987).

Turnip moth would find establishment relatively easy in Australia, and would potentially spread rapidly since climatic conditions are suitable and host plants are present over much of continent. Eradication once adults had moved from the site of incursion would be difficult.

Vigilant quarantine concerning entry of soil associated with host plant material, and against adult moths will be important in avoiding an incursion. Control of established infestations is challenging.

2.1.2 Life cycle

The following description of the life history of the Turnip moth is adapted from CPC (2004), with additional material included throughout the text from the sources referenced. This material is taken from the Pest Risk Review (see PHA website **http://www.planthealthaustralia.com.au/**) for Turnip Moth.

Adults emerge from pupae during the day and only become active after dusk. Females release a sex pheromone on the first night of activity. Females commonly mate only once though can mate up to three times (Gomaa 1978. Males mate on average 6.7 times (at 26°C), being capable of fertilising 590 eggs on average per mating. Both frequency of mating and fertility per mating, decrease with age (Svensson *et al*. 1998).

After a 3-4 day pre-ovipositional period, each female lays 200-2000 eggs, with the number changing with local conditions (Hülbert and Süss 1983). The females oviposit at night, on warm dry soil in places with sparse vegetation such as fallow. The eggs are laid singly or in small batches on the underside of leaves of seedlings, dry plant residues or on soil peds (Jermy, T. & Balázs, K. 1993; Moiseevia 1971; Il'ichev and Galitsina 1981). The eggs hatch in daylight after 3-14 days, depending on the temperature (25C = 5-6 days, 15C = 13-14 days) (Jermy, T. (1952). For the first 20-30 hours the neonates are strongly attracted to light, leading them to the top of the plant ready for wind transportation, which is facilitated by their long hairs (CPC 2004).

When soil is moist, first instar larvae remain on foliage, though this increases mortality (Esbjerg 1988). Under dry conditions, the larvae make short feeding visits to the foliage during the day and hide in the uppermost 1-3 mm of soil at other times. Dry conditions increase feeding activity and development (Esbjerg 1988, 1990). The presence of shelter also reduces mortality (Esbjerg 1990). Small larvae, in particular first-instar larvae, are very sensitive to low temperatures.

The development time for the first two instars varies from 8 to 30 days, and depends on temperature, though this response also depends on the geographical strain of *A. segetum*. In Zimbabwe, for example, the entire larval period may last only 25 days at 30-33°C but it may last for 130 days if the mean temperature is only 15°C (Blair 1976). In Denmark the larval period lasts on average 37 days at 30°C, 110 days at 15°C, and 220 days at 12°C (Esbjerg 1988). Third-instar larvae begin to eat surface roots, increasing in the fourth, fifth and sixth instars which feed voraciously on roots and the bases of stems, causing severe damage. In the Egyptian form of *A. segetum*, a seventh instar may occur (Gomaa 1978). The same 7th instar observed in Europe and was explained with the quality and availability of food plants (Jermy, T. & Balázs, K. 1993). In India *A. segetum* has been recorded as having 5 larval instars and a prepupal stage (Bhagat 1991). This latter stage may in fact be the sixth instar.

The pupal stage lasts for 1-4 weeks (5-7 weeks in continental Europe) depending on latitude and local conditions. In India, a prepupal stage lasts 2-3 days and the pupal period for 12-15 days (Bhagat 1991). In cold climates, the sixth-instar larvae overwintering 3-7 cm below the soil surface and move up to the top 1-3 cm of soil for pupation in the spring (Ogaard and Esbjerg 1993).

Agrotis segetum has one to four (perhaps five) generations per year. For example, there is only one generation in Northern Europe, Northern Siberia and eastern Kazakhstan (Heddergott *et al*. in Sorauer, P. and Blunck, H. (Eds.) (1953) and Moiseeva 1971), two generations in Middle Europe (Jermy, T. & Balázs, K. 1993), Northern Ukraine and southeast Kazakhstan (Moiseeva 1971), three in South Spain, Turkmenistan, Uzbekistan and the majority of the former USSR (Il'ichev and Galitsina 1981), and four overlapping generations in Middle Asia, China (CPC 2004) and Iran (Barbulescu 1973). In warmer regions the duration of the complete lifecycle can be relatively fast; 51-61 days in India (Bhagat 1991). Adults live between 16-19 days at 26°C (Svensson *et al.* 1998), although they may live for less in colder climates (e.g., 15 days in Uzbekistan - Il'ichev and Galitsina 1981).

2.2 Affected hosts

2.2.1 Host range

Turnip Moth has a very wide host range, covering in the order of 25 Families of plants.

Crops and other plants of interest that are hosts include those listed below (Table 1)

Table 1. *Turnip moth hosts*

Family	Common Name	Family	Common Name
Apiaceae	Dill Celery Carrot Fennel Parsley Caraway	**Iridaceae**	Sword lilly
Asteraceae	Endives Sunflower Niger Lettuce Daisy *Aster app.*	**Lamiaceae**	Mint
Brassicaceae	Mustard / Turnip, Rape Cabbage / cauliflower Radish	**Liliaceae**	Leek Onion
Cannabaceae	Hemp	**Linaceae**	Flax
Caryophyllaceae	Carnation	**Malvaceae**	Okra Kenaf Cotton
Chenapodiaceae	Sugarbeet Spinach	Paeoniaceae	**Common peaony**
Convolvulaceae	*Sweet potato*	**Papavereraceae**	Opium Poppy
Cucurbitaceae	*Melon* *Squash*	**Pedaliaceae**	Sesame
Cyperaceae	*Yellow Nutsedge*	**PInaceae**	Sitka spruce Scotts pine

Family	Common Name	Family	Common Name
Euphorbiaceae	*Castor bean* *Rubber*	**Poaceae**	Wheat Barley Oats Maize Rice
Fabiaceae	*Groundnut* *Lucerne* *Clover* *Lupin* *Chickpea* *Soybean*	**Rosaceae**	Apple European strawberry
Grossulariaceae	*Raspberry* *Blackcurrent*	**Solanaceae**	Potato Tomato Capsicum chilli Tobacco Nightshade
Rubiaceae	*Arabica coffee*	**Theaceae**	tea
		Vitaceae	grapevine

It is obvious from the above list of host plants, that Turnip Moth would find many opportunities in Australia to become established should an incursion occur, with both agricultural crops and many horticultural and ornamental plants listed as hosts.

2.2.2 Geographic distribution

Current distribution is as shown in Figure 1(below), as described in the Pest Risk Review, and adapted from CPC (2004).

It is apparent that *Agrotis segetum* Denis & Schiffermüller is established across much of Europe and the Middle East, parts of central Asia and Africa. However, it is not known in North or South America, the Pacific or Australia and New Zealand. Of potential interest is some indication of the pest being known in some Asian countries relatively close to Australia.

Figure 1. *World distribution of Agrotis segetum Denis and Schiffermüller (modified from CPC 2004)*

2.2.3 Symptoms

External feeding on leaves by the first-instar and second-instar larvae of *A. segetum* results in the presence of very small round 'windowpanes' where the larvae have eaten away the upper epidermis and the parenchymal tissue, but left the lower epidermis. External feeding on leaves stalks and stems results in falling leaves, small holes in the stems or cut stems. External feeding on tubers and roots results in a variety of holes.

The activity of the third-instar and fourth-instar larvae is easier to recognise because whole leaves may fall off the plant after being cut through at the base of the stalk. Alternatively, holes may be found on the stems and roots at the soil surface.

A further sign of activity is the presence of leaf pieces partly pulled down into the soil.

Feeding by fifth and sixth instars is very obvious. Whole plants (e.g., lettuces, leeks, maize, cotton, spruce seedlings) fall over, and on root crops (e.g., beetroots) deep holes become visible at and above the soil surface.

In case of developed larger plants, such as maize, the larvae chew into the stem and feed on the soft tissue. Though there is little external sign of damage the plants will fall over in strong wind (Jermy, T. & Balázs, K., 1993).

Damage to underground tubers (e.g., potatoes) may be difficult to recognise before harvest. Damage is far more severe under very dry conditions (Esbjerg 1990) and occurs deeper below the surface.

In Australia the damage to crops may be similar to that of other *Agrotis* species. In this case, the most severe damage is attributed to larvae present when seedlings appear and entire crops may be lost at this early stage. If crops are attacked by larvae later in their development, then far fewer plants are killed by *Agrotis* sp. and the presence of larvae may be difficult to detect (see Hopkins 1987; Michael 1988, 1994). Adults do not feed, except on water and nectar (Il'ichev and Galitsina 1981).

An important complicating factor regarding Turnip Moth is that some other species of *Agrotis* are already present in Australia, and are pests of some important crops that *A. segetum* would also attack. This makes the potential for an incursion to be identified potentially complicated by the possibility of misdiagnosis or confusion of any symptoms on host plants that are colonised by several of *Agrotis species* as not being due to *A. segetum.* As such accurate identification of the plant symptoms and the responsible pest is very important. While adults of the different species are relatively easy to distinguish, the larvae of some *Agrotis* species are similar and may require growing to adults to separate from each other. See notes on diagnostics (Section 2.4 below) and in the Pest Risk Review.

2.3 Entry, establishment and spread

Entry of Turnip Moth is considered unlikely via grain or seeds, with plant material or soil thought to be the major entry route likely.

Introduction of adults by migration (for example from wind-assisted flight) is a possibility, since the moth is a relatively strong flier and some evidence exists of movement on wind over several hundred kilometres in European conditions (Fox, 1973; Kaaber and Andreassen, 1999). When considering any risk from nearby countries, while the relatively sparse distribution in Indonesia suggests otherwise, a remote possibility exists for Turnip moth to colonise Australia on wind currents originating from this country, where it is presently found (see Figure 1).

Such knowledge might suggest some consideration be given to a degree of monitoring for this pest in those areas of northern Australia where such conditions favouring such a migration event may exist.

In general, Turnip moth would be most easily introduced by importation of plants, plant material or soil. For this reason efforts aimed at monitoring such material would be of prime importance.

Given the extensive host range it is likely that following any incursion, establishment and spread would be relatively easy and likely to see the pest become widely distributed.

For these reasons prevention of any incursion is important, with a significant response needing to be quickly mounted in such an event aimed at preventing establishment and spread

2.3.1 Entry potential

Rating: Medium

The pathway most likely to bring the Turnip moth into Australia is as eggs or larvae with various plant material and/or soil, either as imported material or with tourists. Grains and other seeds are not considered a likely avenue for entry.

Turnip moth attacks many plants, with potatoes, beetroot and tomatoes the most affected commodity crops among several other possibilities. Larvae will burrow into tubers and other underground parts, and so imports of these should be closely inspected.

Leafy vegetables and cut flowers may contain eggs or larvae of the Turnip moth as can any soil associated with plants or plant parts. Soil can also contain pupae.

Very little fresh vegetables are imported to Australia from infested countries. However, flowers and potatoes are candidate commodities imported from a range of countries where Turnip moth is known, and should be inspected (along with any associated soil) for *A. segetum* eggs, larvae or pupae.

Larvae are problematic as they shelter in soil, and so may be over-looked. Any imported soil especially where imported with live plants, should be carefully inspected and treated appropriately.

Additionally, there may be a risk of adults contaminating produce during packing, so packaging should also be inspected. The moths can survive up to 26 days, and do not require a food source, though are relatively easy to detect given their size.

It is possible that adults may be found hiding in farm machinery, though the stringent requirements for cleaning and inspection of imported second-hand machinery into Australia minimises the risk of such importation.

However, the cargo areas, empty containers, reused dunnage material and tarpaulins on ships delivering aid to Turnip moth countries may become contaminated by the pest seeking shelter. Risk of introduction on this pathway is high.

While adults are unlikely to be transported alive, eggs can be. Eggs of the Turnip moth are very small, and can be difficult to find as they are usually laid on soil, though when laid in small groups may be easier to detect. The risk of entry by eggs can be prevented by 5-14 days of quarantine to allow time for the eggs to hatch, followed by chemical control (CPC 2004).

There is evidence of incursions overseas with the Turnip moth discovered on several islands, where its introduction was considered human-related. However, previous interceptions of the pest and records on the AQIS Pest and Disease Interception Database are not known. Adult moths - especially worn specimens - can difficult to identify for non-trained inspectors, there is no identification capability of exotic Noctuid moths in Australia, and the pest is not a priority pest of AQIS therefore quarantine entomologists don't try to get the specimens identified. This situation requires some consideration.

The probability of entry for *Agrotis segetum* is rated as **Medium** based on:

- Natural colonisation by wind currents is considered a remote possibility
- While accidental introduction through the importation of eggs, larvae or pupae is considered likely
- Vigilance at entry points should prevent the latter, especially given that no incursions of the moth have occurred to date

2.3.2 Establishment potential

Rating: Medium

Most of Australia (apart from the arid interior) would be highly suitable for the Turnip moth due to the provision of hosts and favourable climatic conditions. Figure 2 illustrates the most likely distribution in Australia.

Its geographical limits tend to be determined by temperature (high and low), though very little of Australia would have temperatures that would restrict the Turnip moth's distribution. Only the drier arid and semi-arid interior of Australia may provide a barrier to establishment, as it has for *A. ipsilon* (see Farrow and McDonald 1987).

The pest is considered able to easily colonise following an incursion, as seen when introduced to remote islands.

The host range is extensive and includes most commercial crops, vegetables, ornamentals and many weeds. Most *Brassica* species would be hosts.

Following an incursion detection may be somewhat difficult. Moth eggs are small and lack species-specific features so their identification is very difficult. While the instars are easily detected from the damage to host plants (e.g., holes, fallen leaves, cut stems), the possibility of misidentification of larvae, especially with larvae of other *Agrotis* species, is likely.

Taxonomic experts cannot identify caterpillars with certainty so specimens should be reared out in PC3 Quarantine facility. Further, adults of the Turnip moth are also easy to misidentify since the distinctive (kidney shape and circular) silvery white markings of the forewing are often invisible on worn specimens, and other *Agrotis* species have very similar markings (see Appendix). Reliable identification is only possible through genitalia dissection.

The reproductive rate of Turnip moth in Australia is expected to be at least as high as observed in other environments, due to the Mediterranean conditions over much of the cropping areas. .Male Turnip moth fertility decreases with each mating, though they fertilise on average 590 of the 200 to 2000 each female lays (Svensson *et al*. 1998). Eggs hatch after 3-14 days, depending on temperature. Australian climatic conditions will be suitable to produce four to five generations per year, and it is likely in some regions winter would be warm enough, and day lengths are long enough, such that diapause will not be triggered. Hence, populations are likely to remain active throughout the year.

The ability of the adults to utilise many host plants ensures that an annual crop host coming to maturity will not eliminate populations.

The probability of establishment for *Agrotis segetum* is rated as **High** based on:

- The wide range of host plants
- The wide tolerance to climatic conditions
- The difficulty in accurate identification and potential for confusion with other species
- Climatic conditions allowing high reproduction rates

2.3.3 Spread potential

Rating: High

Much of Australia has a suitable climate for the moth to spread. Crossing from eastern agricultural and horticultural area to WA would likely require human assistance, though is thought probable once the moth is established.

Within a region spread is also enhanced by the ability of adults to fly strongly, over distances as far as hundreds of kilometres, based on European experience.

There are several natural enemies of *Agrotis spp.* within Australia with these expected to attack *A. segetum*. (see Pest Risk Review). *Trichogramma species* are widely utilised against Turnip moth elsewhere, and would likely be used if necessary in Australia. Several general predators are also available, including assassin bugs, beetles, spiders, scorpions, some birds and bats. However, it is unlikely that predators would successfully contain this pest.

Research has also indicated some viruses, fungal agents, nematodes may be effective in *Agrotis* control, though control is rarely seen to be above 90%.

While there exist several biological control methods that could be employed against Turnip moth, these (either alone or together) would not be considered effective enough to control an incursion or limit spread sufficiently to reduce the spread potential below High. Genetic resistance in host plants is not available. Pheromone traps have shown promise in research, though may not be considered an effective means of limiting spread.

Chemical control presents limited avenues for use in limiting spread, since control is generally relatively low from most commonly used chemical compounds (less than 70% control) and the host range including many vegetable species makes the use of many such compounds problematic.

Some cultural methods have been used with success overseas, though these (for example, flooding o fields during egg laying periods) are unlikely to have wide utility in Australia.

The potential for spread for *Agrotis segetum* is rated as **High** based on:

- The wide range of host plants
- wide tolerance to climatic conditions in Australia
- The adult moths are strong fliers and can be carried long distances on the wind
- Human aided dispersal will also contribute to the rapid spread
- The limited availability of reliable highly efficacious control methods

2.3.4 Economic impact

Rating: Medium

Agrotis segetum is widespread in Europe, Asia and Africa where it can cause significant (up to 30% of production) crop losses, suggesting similar impacts if it became established in Australia. The related species, *A. ipsilon,* causes sporadic damage, based on favourable seasonal conditions, in Australia, with similar experiences with *A. segetum* observed overseas.

Potential impact on production is further complicated by the differences observed between the two species, *A. ipsilon* and *A. segetum*, where the latter is expected to overwinter while the former is expected to migrate to find alternate hosts. As such *A. segetum* is expected to remain year round where it can find and establish in areas with suitable host plants and climatic conditions, reflecting European experience. Some competition is expected to occur between the two species, and some overseas experience suggests *A. ipsilon* may be more competitive, though this may be negated if they prefer different ecological niches.

Considering the expected strong impact climatic and seasonal conditions have on the likely severity of damage from *A. segetum*, and potential for competitive impacts between the two species, the overall economic impact rating is seen as **Medium**.

2.3.5 Environmental impact

Rating: Low

Turnip moth is expected to attack native Australian plant species, within a wide host range, though is expected to potentially favour some environmental weeds, notably deadly nightshade (Khamraev 1980). Additionally, cereal, vegetable and ornamental hosts are likely to be preferred over native species making any environmental impact potentially low.

The related species *A. ipsilon* has had a low environmental impact in Australia, and similar is expected from *A. segetum*. Therefore the environmental impact is expected to be **Low**

2.3.6 Overall risk

Rating: Medium

This rating is based on an index calculated from the medium risk of entry, high risk of establishment and high risk for spread, with the **Medium** risk of entry responsible for this level of overall risk. This does not minimise the difficulties of minimising entry, since detection remains difficult, due to the small size of eggs and ability of larvae to be hidden in soil. In combination with the high establishment and spread potential for this pest, this makes it an important pest for quarantine and incursion management considerations.

2.4 Diagnostic information

2.4.1 Diagnostic protocol

- ***DIRECT DIAGNOSIS OF TURNIP MOTH, EGGS AND LARVAE***

Taxonomic methods using keys and descriptions are adequate for identification of undamaged *Agrotis segetum* adults. Although the forewing markings provide an indication of species, identification with a degree of certainty is by examining the genitalia, with genitalial dissection required. The Pest Risk Review lists the most recent description of the genitals as Fiebiger, 1997.

Eggs are oviposited in soil, are small (0.5mm diameter, 0.4mm height), have 32-35 straight ridges, are white though become grey before larval emergence.

Larvae are difficult to identify and, if possible, should be collected live and reared in PC3 quarantine facility by trained entomologists. Larvae have convex granules on the abdominal body segments, the mentum and submentum is heavily sclerotized and shiny black in colour. Diagnostic images are provided in Appendix I, and on the Pest and Disease Image Library (PaDIL) (**http://www.padil.gov.au/**)

- ***DIAGNOSIS BY SYMPTOMS OF DAMAGE TO HOST PLANTS***

Feeding on leaves by first- and second-instar larvae of *A. segetum* results in small round 'windowpanes' where the epidermis and parenchymal tissue have been eaten, leaving only the lower epidermis. Feeding on leaves, stalks and stems results in falling leaves, small holes or cuts in the stems. External feeding on tubers and roots leaves a variety of holes. Feeding damage from third- and fourth-instar larvae leads to whole leaves falling from being cut through at the base of the stalk. Alternatively, holes may be found on the stems and roots at the soil surface. Fifth and sixth instar damage leads to whole plants falling over, while deep holes are visible at the soil surface in root crops.

2.5 Response checklist

Guidelines for Response Checklists are still to be endorsed. The checklist and short comments below provide a summary of generic requirements to be considered within a Response Plan:

Destruction methods for plant material, soil and disposable items:

- Suspected contaminated soil would be expected to provide some risk of containing eggs and larvae, hence destruction would need to cater for these

Disposal procedures

- Mainly needed for contaminated soil and adults trapped in pheromone or other non-destructive traps

Quarantine restrictions and movement controls

- Need to consider active flight characteristics of adults, plus contaminated soil movement

Decontamination and farm cleanup procedures

- Consider contaminated soil management

Diagnostic protocols and laboratories

- Consider difficulties in having required expertise needed for diagnosing immature life stages, plus laboratory experience in preparation of specimens for microscopic genitalial examination

Trace back and trace forward procedures

- Consider the wide host range and potential introduction avenues (eggs or larvae in soil) adults and delay in egg hatching times. Will need AQIS assistance.

Protocols for delimiting, intensive and ongoing surveillance

- Active flight makes design and operation of surveys difficult, need to take into account wind direction and speed, overwintering potential.

Zoning

- Much of Australia is likely to provide acceptable climatic conditions though presence of hosts may enable elimination of some areas.

Reporting and communication strategy

- Consider number of agricultural and horticultural crops and interested parties requiring communication with

Additional information is provided by Merriman and McKirdy (2005) in the Technical Guidelines for Development of Pest Specific Response Plans (see PHA website).

2.6 Delimiting survey and epidemiology study

Such surveys should consider the initial area of incursion / detection, in addition to information able to be gained from trace back / trace forward activities. However, this is complicated by the potential similarity of symptoms of damage to that of other stem boring insects and the active flight characteristics of the adults. In consideration of the latter feature, weather and wind conditions would need to be taken into account in any surveys following detection. Additionally, the wide host range and climatic adaptability of the Turnip moth makes any surveying activity potentially much wider geographically than for many other pests.

2.6.1 Sampling method

The choice of any sampling method is best informed by knowledge of the biology of Turnip moth in combination with accepted detection methods, and also if the sampling is in response to an incursion where eradication may be the objective as opposed to where management of an established population is desired.

In the case of Turnip moth the use of pheromone or light traps would be suitable to detect the presence of adults. Some hand sampling of soil (for eggs or larvae) or host plants for signs of feeding damage would also be suitable, notably where an incursion has been recorded, in surrounding areas.

When planning any surveys the following features should be taken into account:

- Adults can fly considerable distances, especially when assisted by prevailing winds. Some reports of flight lengths of over 7km, though much greater distances are possible when wind assisted. Surveys should, thus, be relatively wide, ranging several kilometres from a detection site with a bias in a downwind direction

- Eggs and larvae can be difficult to detect in soil, so attention should be paid to finely inspecting any soil samples taken from surveyed areas suspected of potentially containing eggs or larvae, though it is very difficult to identify eggs or larvae as Turnip Moth
- Adult Turnip Moths are similar in appearance to other *Agrotis* spp. present in Australia
- Damage from feeding Turnip Moths can resemble feeding damage from other pests
- Moths are relatively easy to see and are reasonably able to be distinguished from other moths (including other *Agrotis* species) as adults
- In addition to pheromone and light traps (Nowinszky *et. al* 2010), sweep nets can be used for collecting adults in host crops (Russell IPM supply Pheromone traps for Turnip Moth). Pheromone traps are generally to be preferred

2.6.1.1 NUMBER OF SPECIMENS TO BE COLLECTED

Ideally, it is best to collect multiple specimens from as many life stages as can be found. Adults will in most cases be the easiest to find and collect and are desirable as the adult life stage is the easiest to use for identification.

It is important to record the host plant, location (including GPS co-ordinates if possible), distance and direction to identifiable landmarks, and other host crops or plants where the specimen has been located. If private land, note the landholders' contact details.

2.6.1.2 HOW TO COLLECT PLANT SAMPLES

Where adult moths are unable to be collected, it is possible that plant material showing feeding damage or with larvae attached may be collected. The likely plant parts to be collected will be leaves where larvae are feeding on these, though they also prefer to bore at the base of plants and into tubers or underground parts.

2.6.1.3 HOW TO PRESERVE PLANT SAMPLES

Plant samples with immature life stages associated or attached should be packed between dry paper sheets, or (moistened paper for leaves), and sealed in plastic bags. Double bagging is recommended with additional paper also placed in outer bags. Bags should be placed in crush resistant containers for transport.

2.6.1.4 HOW TO TRANSPORT PLANT MATERIAL

Sample material can be transported in vehicles or registered courier methods.

Where possible samples should be kept away from extreme temperatures, and the use of refrigeration equipment should be used where possible.

2.6.1.5 HOW TO PRESERVE INSECT SAMPLES

Adults should be killed by standard methods – freezing, cyanide, ethyl acetate

Varying concentrations of ethanol for preserving Lepidopteran specimens have been recommended, ranging from 70-95%. Ethanol should be used where morphological identification of adult moths is planned, though it is not ideal as a preservative where DNA analysis is to be undertaken.

DNA methods are currently not used for identification of Turnip moth, though specimens planned to be kept for future analysis should be stored in absolute ethanol, though acetone has been recommended (Mandrioli *et al.,* 2006) as a possible alternative to ethanol if DNA analysis is planned. Acetone has the additional advantage of being effective at preserving morphological features of Lepidopteran specimens at room temperature. Future DNA analysis may assist in determining origin of any incursion, or for otherwise characterizing features of an incursion.

Where taxonomic expertise is readily available and identification can be carried out quickly it may be practical to keep adult moths alive or kill and relax the insect immediately prior to transport. Live insects (any life stage) should not be transported unless it is considered essential, and then such that containers are only opened in PC3 or QC3 containment facilities.

2.6.1.6 HOW TO TRANSPORT INSECT SAMPLES

Vials containing the samples in a preservative should be sealed to avoid leakage and packed in a manner to minimise shock to the vials (i.e. with cushioning material in a strong box). It is important to ensure that vials are filled with preservative so as to remove excess air that through movement of the vial will allow agitation of the preservative and quickly degrade the specimen.

Transport/airline regulations may preclude the transportation of ethanol or acetone. Contact the relevant transport authority or company for advice.

Live insects should in general not be transported unless considered essential to do so, and if so, must be packaged in strong, sealed containers.

2.6.1.7 REGARDING QUARANTINE

Where a quarantine situation occurs, special authority will be needed to remove live exotic insects from the quarantine area.

On receipt of the samples the diagnostic laboratory should follow strict quarantine and processing guidelines. In keeping with ISO 17025 refer to PLANTPLAN (Plant Health Australia, 2010).

2.6.2 Epidemiological study

The extent of any infestation following an incursion will depend on the initial population size and whether conditions have been favorable for the pest to spread from the initial location. Sampling should be based upon the origins of the initial sample(s). Factors to consider will be:

- The proximity of other host plants to the initial infestation source. Turnip moth has a wide host range including many crop, ornamental and native plants, so that a wide survey will be needed covering many host plant candidates in a relatively wide area
- Machinery or vehicles that have been into the infested area or in close proximity to the infestation source, especially those that can or do carry soil

- The extent of human movements into and around the infested area. A possible link to the recent importation of plant material or soil from other regions should also be considered
- The source of any nursery or horticultural stock propagation material
- If any other crops have been propagated from the same source and/or distributed from the affected area or property
- Turnip moth can have several generations per year under most environmental conditions in Australia
- It is capable of surviving cold weather through diapauses at the egg life cycle stage
- Adults can spread many kilometers, as they are strong fliers

2.6.3 Models of spread potential

No suitable model of spread of Turnip moth has been found. Some work relating spread to weather conditions has been reported in Norway, though this is for management of the pest in 'normal' situations and not in an incursion situation.

2.6.4 Pest Free Area guidelines

Determination of Pest Free Areas (PFAs) should be completed in accordance with the International Standards for Phytosanitary Measures (ISPMs) 8 and 10 (IPPC, 1998a, 1999).

Points to consider are:

- Design of a statistical delimiting field survey for symptoms on host plants and for the presence or absence of Turnip moth eggs, larvae, pupae and especially adults
- Surveys should consider alternative hosts given the wide host range, aside from the infested incursion host
- All relevant information (including absence of the pest) should be recorded
- Plant sampling should be based on a representative number of plants taken at random from each crop
- Where larvae are suspected observations should be of low stem and soil areas, looking for typical cutworm symptoms, including damage to any tubers
- Survey around transport routes of any machinery that may have inadvertently transported the pest

Additional information is provided by the IPPC (1995) in Requirements for the Establishment of Pest Free Areas. This standard describes the requirements for the establishment and use of pest free areas as a risk management option for phytosanitary certification of plants and plant products. Establishment and maintenance of a PFA can vary according to the biology of the pest, pest survival potential, means of dispersal, availability of host plants, restrictions on movement of produce, as well as PFA characteristics (size, degree of isolation and ecological conditions).

2.7 Availability of control methods

While several methods are available for control of Turnip moth, none have proven highly effective and would be less than ideal for eradication programs.

2.7.1 General procedures for control

2.7.2 Control if small areas are affected

If only larvae or pupae are detected before any distribution of the infested plant material or soil, normal quarantine procedures should be followed. It is likely that eradication of a small area infestation of larvae or pupae will only be achievable where severe control methods are employed for quite small areas incursions (e.g. an isolated nursery, small numbers of affected host plants in a crop showing cutworm symptoms). It is unlikely that eradication would be achieved after larvae or pupae are detected in a wider field situation.

If a preliminary survey has indicated that no more than one localised infestation is present, and that no adults have emerged from that area, then in that isolated area eradication may be achieved if a “scorched earth” policy is followed. Remove all possible host plant material (dry or living) within a 5m (or larger upon advice) radius of the affected area and dispose through burning. Associated soil or below ground plant parts should be examined closely and also treated so as to kill any larvae or eggs. Keep the area within a 10 m radius host plant-free by spraying with an appropriate herbicide. Continue to keep the area bare of any host plants for at least 18 months. If a thorough surveillance reveals more than one further point infestation indicated by either eggs (difficult to see), larvae or pupae or any signs of adults having emerged and active from the first find, then the eradication campaign should be reconsidered.

2.7.3 Control if large areas are affected

Where large areas are affected and adults are suspected or observed as having been active the likelihood of eradication or containment is extremely small. Treatment of large areas with insecticides is unlikely to stop all pupae developing and will be less than totally effective against adults.

Pheromone traps, especially intensively employed in a defined area where moths are thought to have remained may be effective in controlling enough moths for eradication to be attempted.

2.7.4 Cultural control

No cultural control methods are available that can be readily and easily employed for control of Turnip moth. Some practices such as fallowing and irrigation management have been effective at assisting with reducing moth damage overseas. However these are not considered suitable for general Australian conditions and not in an incursion event.

2.7.5 Host plant resistance

No host plant resistance is known to exist against Turnip moth at present.

2.7.6 Chemical control

While several insecticidal compounds are used for control of Turnip moth, these are not highly effective in general. Organophosphates have been reported as only providing less than 70% control (Geissler and Schliephake 1991).

It is likely that the bacterially produced *Bacillus thuringiensis* (*Bt*) toxin may have a role in control of Turnip moth larvae, since it is generally a useful strategy against caterpillar pests. However, no Australian data are available.

As such, chemical control should not be relied upon for highly effective control of Turnip moth, and a variety of approaches will be needed.

2.7.7 Mechanical control

Mechanical control activities against adults will be in general unreliable, apart from the use of pheromone traps and destruction of caught insects. This technique may well for the basis of control of any incursions of Turnip moth.

It is likely that some cultivation of soil where an infestation is known for mechanical control of larvae or especially pupae would be useful.

2.7.8 Biological control

There are several natural control agents of Turnip moth, including predators, parasites, nematodes, fungi and viruses.

Some promising results of research with biological agents have been reported, for example:

- Some viruses, (baculoviruses) have given over 90% control in research (Geissler and Schliephake 1991, El-Salamouny et al. 2003)
- Fungal agents, for example, *Metarrhizium anisopliae* have given over 90% mortality (Steenberg and Ogaard 2000)
- Some nematodes have given control similar to that from chemical insecticides (López-Robles and Hague 2003)
- Parasites, for example *Trichogramma* species are used overseas in mass release strategies (Nazirov and Egamnazarov 1985)

While these and other potentially useful bio-control agents and predators are effective against Turnip moth, they are unlikely to be either easily available, or easily employed in an incursion situation, and should not be relied upon for control.

However, pheromone traps are an extension of biological control and are likely to be a very useful tool for both surveying activities and control of an incursion or outbreak of Turnip moth (see Del Socorro and Gregg 2004).

3 Course of action – eradication methods

3.1 Destruction strategy

The decision to eradicate should be based both on the potential economic impact of host damage resulting from Turnip moth infestation and on technical feasibility. Eradication costs must factor in long-term surveys to prove the success of the eradication program. Up to two years with no detections of the pests will be necessary to confirm that no Turnip moth remain before pest free status can be declared.

No specific eradication matrix has been determined for Turnip moth, however the general decision process as outlined in Figure 2 should be followed in determining if an incursion of this pest will be eradicated or managed/contained. The final decision between eradication and management will be made through the National Management Group.

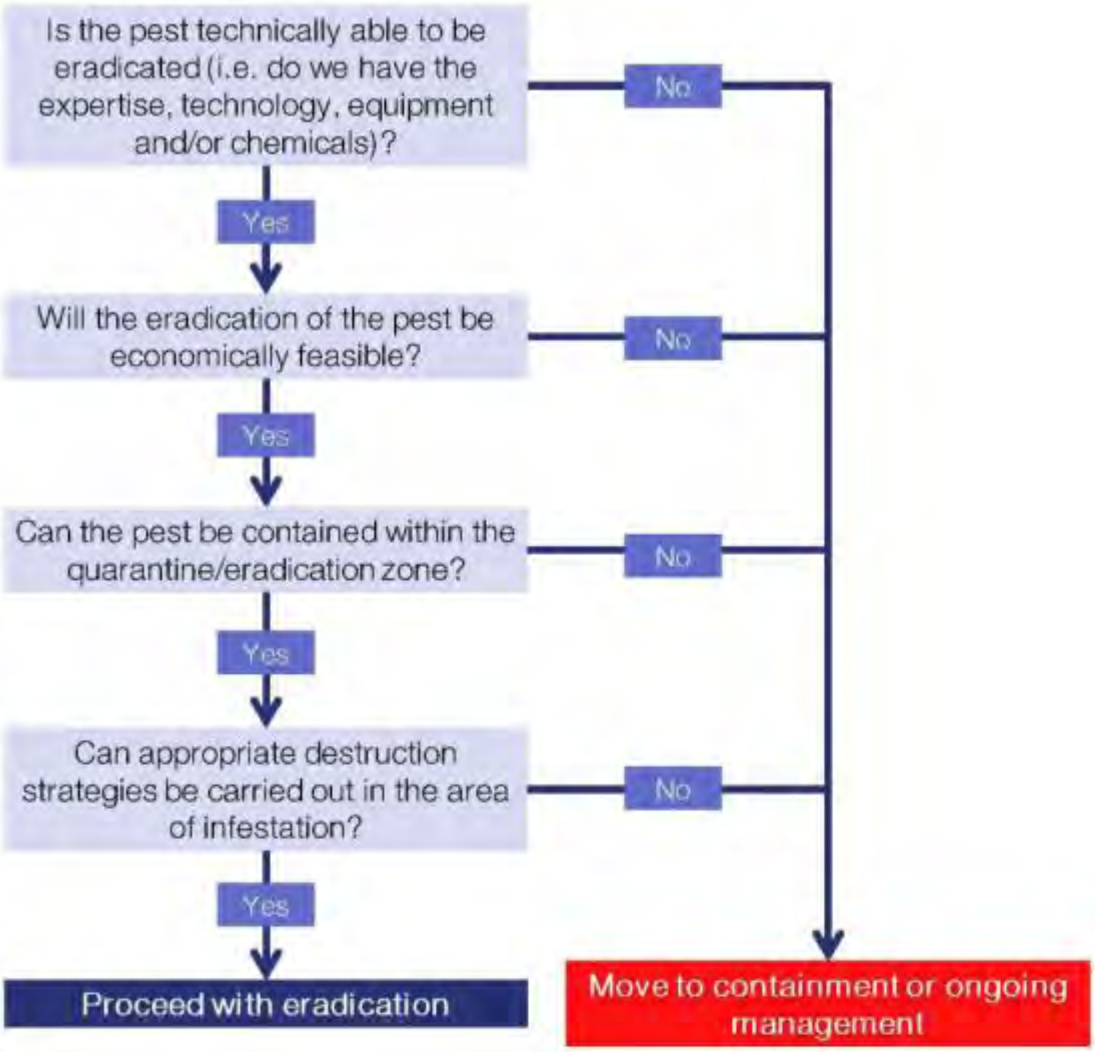

Figure 2 *Decision outline for the response to an exotic pest incursion*

3.1.1 Destruction protocols

General protocols:

- Disposable equipment, infested plant material or growing media/soil should be disposed of by autoclaving, high temperature incineration or deep burial
- Any equipment removed from the site for disposal should be double-bagged
- Machinery used in destruction processes need to be thoroughly washed, preferably using a detergent or farm degreaser

Turnip moth destruction strategy:

- Knock down populations with a surface insecticide or Bt bacteria.
- Pheromone traps should be readily employed where any adults are suspected
- Infested plant parts and tubers can then be destroyed by enclosed incineration or deep burial
- Methyl bromide is effective at killing eggs, larvae and pupae and should be used where such plant parts and infested soil can reasonably be treated
- Similarly, planting media should be sterilised by autoclaving or methyl bromide, or disposed of through deep burial

3.1.2 Decontamination protocols

Machinery, equipment and vehicles in contact with infested plant material or growing media/soil, or present within the Quarantine Area, should be washed to remove plant material and growing media/soil using high pressure water or scrubbing with products such as a degreaser or a bleach solution (1% available chlorine) in a designated wash down area. When using high pressure water, care should be taken not to spread plant material. High pressure water should be used in wash down areas which meet the following guidelines:

- Located away from crops or sensitive vegetation
- Readily accessible with clear signage
- Access to fresh water and power
- Mud free, including entry and exit points (e.g. gravel, concrete or rubber matting)
- Gently sloped to drain effluent away
- Effluent must not enter water courses or water bodies
- Allow adequate space to move larger vehicles
- Away from hazards such as power lines
- Waste water, growing media/soil or plant residues should be contained (see Appendix 18 of PLANTPLAN [Plant Health Australia, 2010])
- Disposable overalls and rubber boots should be worn when handling infested plant material or growing media/soil in the field. Boots, clothes and shoes in contact with infested plant material or growing media/soil should be disinfected at the site or double-bagged to remove for cleaning
- Skin and hair in contact with infested plant material or growing media/soil should be washed

Procedures for the sterilisation of plant containers and growing media are provided within the BioSecure HACCP Guidelines, however, in the event of a Turnip moth incursion, procedures outlined in the BioSecure HACCP Guidelines may not be effective for the destruction of the pest. Any sterilisation procedure must be approved for use in the endorsed Response Plan.

3.1.3 Priorities

- Confirm the presence of the pest, noting the life stage(s) present. Take particular note of adults
- Prevent movement of vehicles and equipment through affected areas, checking for any adults in vehicles located just outside affected areas
- Stop the movement of any plant material (including below ground parts) and soil that may be infested with the pest
- Determine the strategy for the eradication/decontamination of the pest and infested host material and soil
- Determine an appropriate communication strategy for the relevant industry or infested area
- Determine the extent of infestation through survey and plant material trace back

3.1.4 Plants, by-products and waste processing

Any growing media/soil or infested plant material removed from the site should be destroyed by (enclosed) high temperature incineration, autoclaving or deep burial.

As the pest (including adults) can be mechanically transported, plant debris and any suspected soil from the destruction zone must be carefully handled and transported for destruction.

Infested areas, crop areas or nursery yards should remain free of susceptible host plants until the area has been shown to be free from the pest.

3.1.5 Disposal issues

Particular care must be taken to minimize the transfer of infested plant material or insects from the area.

Host material, including leaf litter, should be collected and incinerated or double bagged and deep buried in an approved site.

3.2 Quarantine and movement controls

The November 2010 (version 2) of PLANTPLAN, (Plant Health Australia) should be consulted

3.2.1 Quarantine priorities

Plant material and soil at the site of infestation is to be subject to movement restrictions.

Machinery, equipment, vehicles and disposable equipment in contact with infected plant material or soil to be subject to movement restrictions.

Adult Turnip moths are strong fliers and can be dispersed from emergence sites by wind currents for several kilometres, making establishment of quarantine difficult.

3.2.2 Movement control for people, plant material and machinery

Once established Turnip Moth will be very difficult to eradicate. Therefore, any zoning, quarantine or movement controls will be directed to containment and management unless detection occurs very soon after establishment and adults have not moved away from the initial incursion site. If Restricted or Quarantine Areas are practical, movement of equipment or machinery should be restricted and movement into the Area only occurs by permit.

The industry, and potentially other industries involved with alternate host plant crops will need to be informed of the location and extent of the incursion.

Movement of people, vehicles and machinery, from and to affected farms, must be controlled to ensure that infected soil or plant debris is not moved off-farm on clothing, footwear, vehicles or machinery. This can be achieved through:

- Signage to indicate quarantine area and/or restricted movement in these zones
- Fenced, barricaded or locked entry to quarantine areas
- Movement of equipment, machinery, plant material or soil to be by permit only
- Clothing and footwear worn at the infected site should either be double-bagged prior to removal for decontamination or should not leave the farm until thoroughly disinfected, washed and cleaned
- Where no dwellings are located within these areas, strong movement controls should be enforced
- Where dwellings and places of business are included within the Restricted and Control Areas movement restrictions are more problematic, however limitation of contact with infested plant areas should be enforced
- If a production nursery or property is situated within the Restricted Area, all trading must cease and no material may be removed without permission, due to the high likelihood of pest spread. Movement restrictions would be imposed on both host and non-host material
- Residents should be advised on measures to minimise the inadvertent transport of Turnip moth (especially adults and potentially infested soil) from the infested area to unaffected areas
- Plant products, including tubers or similar underground plant parts, must not be removed from the site or used for feeding stock due to the risk of moving larvae, pupae or eggs
- All machinery and equipment should be thoroughly cleaned down with a pressure cleaner prior to leaving the affected location. The clean down procedure should be carried out on a hard surface, preferably a designated wash-down area, to avoid mud being re-collected from the affected site onto the machine

3.3 Zoning

The size of each quarantine area will be determined by a number of factors, including the location of the incursion, biology of the pest, climatic conditions and the proximity of the infested property to other infested properties and areas of host plants.

The National Management Group will determine this during the production of the Response Plan.

Further information on quarantine zones in an Emergency Plant Pest (EPP) incursion can be found in Appendix 10 of PLANTPLAN (Plant Health Australia, 2010). These zones are outlined below and in Figure 3.

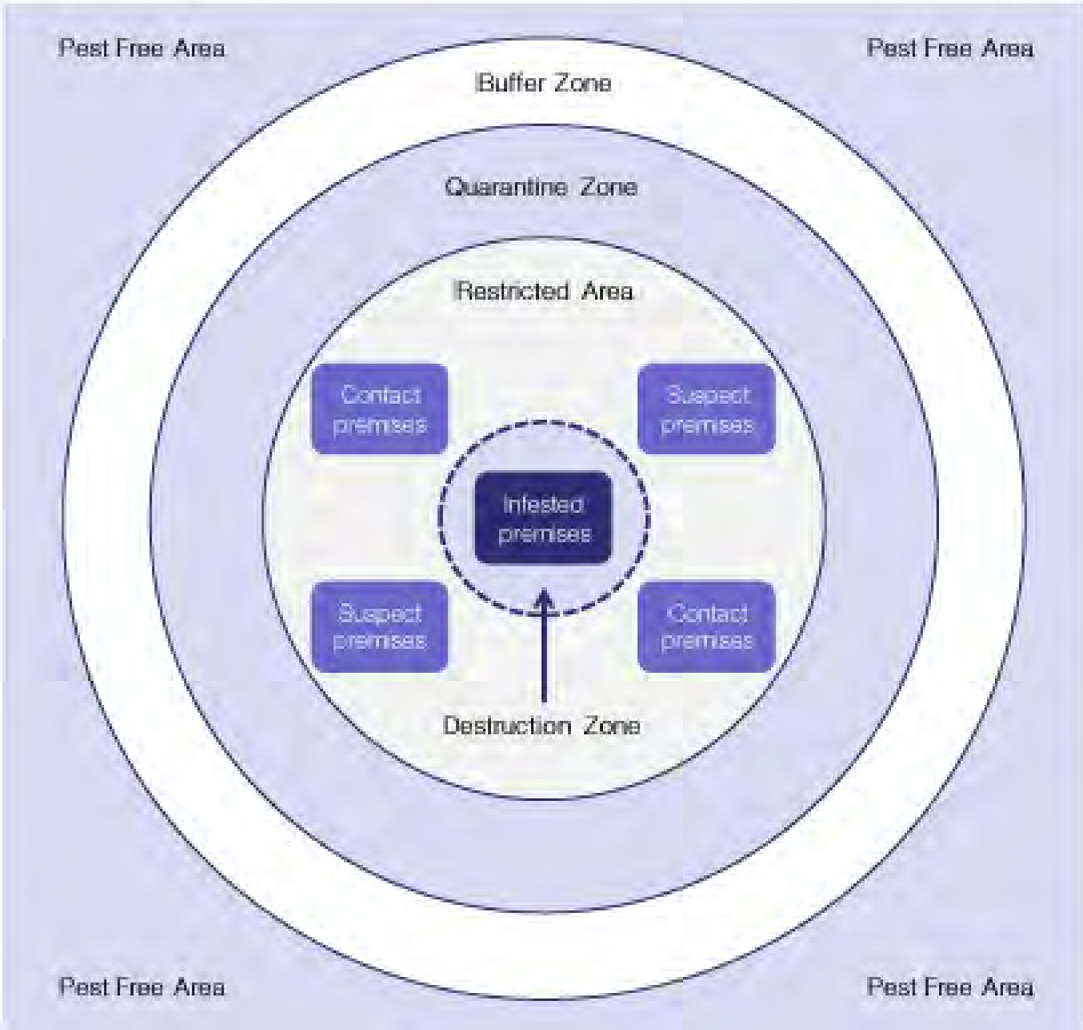

Figure 3 *Schematic diagram of quarantine zones used during an EPP incursion (not drawn to scale)*

3.3.1 Destruction Zone

The size of the destruction zone (i.e. zone in which the pest and all host material is destroyed) will depend on the ability of the pest to spread, distribution of the pest (as determined by delimiting surveys), climatic conditions, time of season (and part of the pest life cycle being targeted) and factors which may contribute to the pest spreading.

The entire crop or population of host plants in the zone should be destroyed after the level of infection has been established. The delimiting survey will determine whether or not neighbouring host plants are infected and need to be destroyed. The Destruction Zone may be defined as contiguous areas associated with the same management practices and host plant presence as the infected area (i.e. the entire nursery, glasshouse, paddock or farm if spread could have occurred prior to the infection being identified). If the movement of *A. segetum* to neighbouring areas appears likely through the flight of adults, host plants in these areas will also need to be destroyed. Particular care needs to be taken to ensure that soils and plant material are not moved into surrounding areas not showing symptoms of moth infestation. Care needs to be taken to limit mud being spread on boots and protective clothing.

3.3.2 Quarantine Zone

The Quarantine Zone is defined as the area where voluntary or compulsory restraints are in place for the affected property or properties. These restraints may include restrictions or movement control for removal of plants, people, growing media/soil or contaminated equipment from an infested property.

3.3.3 Buffer Zone

A Buffer Zone may or may not be required depending on the nature of the incursion. It is defined as the area in which the pest does not occur but where movement controls or restrictions for removal of plants, people, soil or equipment from this area are still deemed necessary. The Buffer Zone may enclose an infested area (and is therefore part of the Control Area) or may be adjacent to an infested area.

3.3.4 Restricted Area

The Restricted Area is defined as the zone immediately around the infested area and suspected infested area. The Restricted Area is established following initial surveys that confirm the presence of the pest. The Restricted Area will be subject to intense surveillance and movement control with movement out of the Restricted Area to be prohibited and movement into the Restricted Area to occur by permit only. Multiple Restricted Areas may be required within a Control Area.

3.3.5 Control Area

The Control Area is defined as all areas affected within the incursion. The Control Area comprises the Restricted Area, all infested areas / premises and all suspected infested areas / premises and will be defined as the minimum area necessary to prevent spread of the pest from the Quarantine Zone. The Control Area will also be used to regulate movement of all susceptible plant species to allow trace back, trace forward and epidemiological studies to be completed.

3.4 Decontamination and farm clean up

Decontaminant practices are aimed at eliminating the pest thus preventing its spread to other areas.

3.4.1 Decontamination procedures

General guidelines for decontamination and clean up:

- Refer to PLANTPLAN (Plant Health Australia, 2010) for further information

- Keep traffic out of affected area and minimize in adjacent areas
- Adopt best-practice property hygiene procedures to retard the spread of the pest between growing areas/fields and adjacent properties
- Machinery, equipment and vehicles in contact with infested plant material or growing media/soil present within the Quarantine Zone, should be washed to remove growing media/soil and plant material using high pressure water or scrubbing with products such as a degreaser or a bleach solution in a designated wash down area
- Only recommended materials are to be used when conducting decontamination procedures, and should be applied according to the product label
- Infested plant material or soil should be disposed of by autoclaving, high temperature (enclosed) incineration or deep burial

3.4.2 Decontamination if pest is identified in a small or a large area.

- ***FOR SMALL AREAS:***

Decontamination of small areas, for example an individual nursery, glass house, or small outside crop area may need to be determined on an individual basis involving the farm or site manager, the state or territory departmental officers and/or federal officers. The decontamination procedures should consider:

- the source and location of the infestation
- the type of enterprise (e.g. farm paddock, nursery, glasshouse)
- life stage of the moth infestation
- Climatic conditions
- the nature of any buildings where the infestation has occurred
- the proximity to other areas where host plants may exist
- workplace safety matters
- environmental impact of the disinfectant protocol
- legislative requirements (occupational health and safety, environmental protection, chemical use)

- ***FOR LARGE AREAS:***

Considerations for large areas include:

- A large area may be affected, especially if adults have begun movement
- Limited or no control over movement of plants, people or agricultural machinery
- Limited or no control over stock movements
- Limited or no ability to thoroughly decontaminate the wider area
- Decontamination restricted to movement of personnel and equipment in and out of the infected area
- Potentially a very wide group of stakeholders

Large areas where Turnip moth infestations have occurred, such as broadacre cropping areas, are areas where normally there is little or no control of movement of agricultural machinery, plant material and personnel. As such, decontaminating these areas as part of an incursion response will often be difficult to manage due to the lack of control of these movements and the large areas potentially involved.

Decontamination procedures may have a significant impact on the environment, and a wide group of stakeholders might be affected by control measures.

Decontamination programs will tend to be limited to decontamination of personnel, vehicles, equipment plants and soil moving out of the infected area. There may be multiple access points that need to be considered as decontamination points.

The potential exists for litigation resulting from recommendations made to the general public or action taken by authorities. Under such circumstances, decontamination procedures must be simple and safe to people and equipment. Decontamination procedures should rely primarily on good cleaning procedures, using products that would normally be available for such purposes. Decontamination control measures that may be applied include:

- installation of signage and wash down bays at entry and exit points, or at strategic points around the control area
- production of technical literature explaining how the general public may identify the moth and undertake reporting, control and cleaning or disinfection procedures
- for commercial operators working within the infected area, establishment of logbook systems that document when decontamination procedures are undertaken
- Communication and training activities for those frequently entering or leaving infected areas

3.4.3 General safety precautions

For any chemicals used in the decontamination, follow all safety procedures listed within each Material Safety Data Sheet.

3.5 Surveillance and tracing

3.5.1 Surveillance

Detection and delimiting surveys are required to delimit the extent of the outbreak, ensuring areas free of the pest retain market access and appropriate quarantine zones are established.

Initial surveillance priorities include the following:

- Surveying all host growing properties and businesses in the pest quarantine area
- Surveying all properties and businesses identified in trace-forward or trace-back analysis as being at risk
- Surveying all host growing properties and businesses that are reliant on trade with interstate or international markets which may be sensitive to Turnip moth
- Surveying production nurseries or other plant suppliers selling at-risk host plants
- Surveying other host growing properties and areas

Awareness is an essential surveillance tool. Information about the risks posed by Turnip moth should be regularly made available to target groups through media outlets. This should be supplemented with readily available and referable information sources such as exotic pest data sheets and Internet sites. The wing characteristics of Turnip moth adults are distinctive and colour pictures plus point-form information (e.g., Appendix 1), should feature in any information aimed at target groups. However handling of the specimens by inexperienced persons will make identification very difficult. Horticulture extension officers in State Departments of Agriculture or Primary Industry should be aware of the pest and have information readily available for occasional reminders in grower newsletters or production talks. Ideally, all target groups should have ready access to State Departments of Agriculture or Primary Industry run free identification services that can confirm the identity of suspect adults, pupae or larvae and/or refer them to specialists.

▪ *CONSIDERATIONS FOR GROWERS, AGRIBUSINESSES AND WHOLESALERS/RETAILERS:*

Cereal crop, cut flower and vegetable growers, and the businesses that supply them and market their produce, should have information regularly made available through trade journals and industry information sources about Turnip moth. Industry biosecurity plans developed for the relevant industries should be widely promoted through the relevant producer associations.

▪ *CONSIDERATIONS FOR URBAN COMMUNITIES AND HOME GARDENERS:*

There is a high likelihood that the initial site of incursion of Turnip moth can be in urban areas. Therefore, home gardeners, nurseries and media catering to these groups should be targeted in “community surveillance” programs. Displays at shows and events aimed at urban communities can have information leaflets available. State Departments of Agriculture or Primary Industry that have information and/or technical services for urban target groups should have readily available information on Turnip moth, perhaps of the same type as made available to Grower groups by Extension officers.

▪ *CONSIDERATIONS FOR QUARANTINE AUTHORITIES (AUSTRALIAN QUARANTINE AND INSPECTION SERVICE)*

AQIS information on ICON (Import Conditions database) should include information on pests such as Turnip moth, especially where queries about commodities on risk pathways from risk countries are made by importers or the public. Such information should be available to AQIS inspectors, who should receive training that includes such information. Of particular importance is knowledge of risk countries where Turnip moth occurs, and the risk pathways that could lead to the introduction of Turnip moth. The aim of this approach is an awareness of what might be found during an inspection. Also it is advisable to AQIS to run continuously *Agrotis segetum* specific pheromone traps at every point of entry.

General surveillance based on awareness that triggers recognition of an insect that is exotic, out of place, or unusual relies on random recognition and is qualitative, rather than quantitative and directed.

▪ *TARGETTED SURVEILLANCE*

Targeted surveillance requires specified sampling plans based on knowledge of pest biology, accepted detection method, and statistically defined methods that allow estimation of population presence, absence and / or size. The main role for targeted surveillance is to determine the likelihood of presence or absence of an exotic organism. Identifying the presence of the Turnip moth is easily achieved by the use of specific pheromone traps. Symptoms produced on host plants can be produced by several different species of *Agrotis* commonly occurring in Australia, therefore such symptoms are not suitable for establishing the presence or absence of the Turnip moth.

In the pest's current distribution, population monitoring is achieved by pheromone and also light traps, particularly in geographical areas with extreme fluctuations such as north-west Europe (CPC 2004).

The number of moths caught and the subsequent weather conditions may influence the type and timing of control treatment and give the ability to predict an outbreak. This species is also readily captured as adults at light traps, although such traps do not discriminate between pest and native species. Light traps are more expensive, more complicated and more prone to malicious damage than pheromone traps. Also Lepidopteran insects usually become very worn and damaged in light traps therefore pheromone traps should be used.

Targeted surveillance for Turnip moth may be conducted with different objectives:

1 To provide a statistically reproducible sampling methodology to establish the absence of Turnip moth at a defined level of confidence

2 To determine presence or absence of the pest in a district or region, In the event that it has been found elsewhere and it is necessary to delimit the extent of the infestation

3 To determine the size of a population that has been detected, with a view to deciding on treatment actions that may be taken. This is the most usual situation in determining action levels in commercial pest control. Most of the sampling methodologies reported in the literature have this as their aim

The most common and efficient method of determining the presence or absence of adult Turnip moths have been with attractant traps, usually pheromone based (Esbjerg 2003). With this method it is not possible to determine the abundance of larvae in a crop but initially it is not necessary. Hand sampling is a secondary method to estimate the number of larvae per square metre for control purposes. This sampling method is designed to assess action thresholds for control of Turnip moth in infested regions. It is not applicable to incursion detection or management, where eradication may be the objective. However, it may be of value in incursion management if comparative data on population size is important.

Other methods utilised include light traps (e.g. Jermy, T. and Balázs,K.,1993, and Kiss *et al.* 2004), and radar has recently been used to monitor the movement of moth populations (Svensson *et al.* 2001). However, these methods were employed for research into the behaviour of the moth, already established, not for targeted surveillance. Visual inspection of crop damage, such as fallen leaves and holes in nuts and tubers has been used but usually it is too late to save crops with control methods by the time this damage is inflicted (CPC2004)

As Industry biosecurity plans are developed, it will be necessary to establish baseline data for occurrence of native or already established exotic pests in host crop areas, and checking for potentially exotic pests. Structured sampling plans are required to ensure sampling data from different regions and at different times are comparable, and should involve techniques capable of detecting each of the pest species that are targeted. The preceding methods outlined for Turnip moth should be incorporated in such sampling schemes. Targeted surveillance, especially in vegetation production areas, should include inspection of non-crop host plants, such as Solanaceous plants and other weeds.

- ***EXOTIC PEST SURVEY***

Although the potential for entry into Australia by the Turnip moth is medium, the most desirable situation for control is continued surveillance of imported commodities and people from infested regions entering Australia. Once established, eradication of the Turnip moth is very unlikely and the pest should reach populations large enough to ensure relatively fast detection. Exotic pest surveys of regions surrounding Australia (e.g. islands) is necessary to determine if the moth will possibly enter Australia through natural dispersal. If *A. segetum* is included in exotic pest surveys, then all hosts, including potential Australian native host plants, must be included. Surveys around port and airports must include sampling of plants such as Freesias.

3.5.2 Survey regions

Establish survey regions around the surveillance priorities identified above. These regions will be generated based on the zoning requirements, and prioritised based on their potential likelihood to currently have or receive an incursion of this pest. Surveillance activities within these regions will either allow for the area to be declared pest free and maintain market access requirements or establish the impact and spread of the incursion to allow for effective control and containment measures to be carried out. Detailed information regarding surveys for Turnip moth have been outlined elsewhere (Section 3.5.1 above) in this plan.

Steps outlined in Table 2 form a basis for a survey plan. Although categorised in stages, some stages may be undertaken concurrently based on available skill sets, resources and priorities.

***Table 2** Phases to be covered in a survey plan*

Phase 1	Identify properties that fall within the buffer zone around the infested premises Complete preliminary surveillance to determine ownership, property details, production dynamics and tracings information (this may be an ongoing action)
Phase 2	Preliminary survey of host crops in properties in buffer zone establishing points of pest detection
Phase 3	Surveillance of an intensive nature, to support control and containment activities around points of pest detection
Phase 4	Surveillance of contact premises. A contact premises is a property containing susceptible host plants, which are known to have been in direct or indirect contact with an infested premises or the pest. Contact premises may be determined through tracking movement of materials from the property that may provide a viable pathway for spread of the pest. Pathways to be considered are: • Items of equipment and machinery which have been shared between properties including bins, containers, irrigation lines, vehicles and equipment • The producer and retailer of infested material if this is suspected to be the source of the outbreak • Labour and other personnel that have moved from infested, contact and suspect premises to unaffected properties (other growers, tradesmen, visitors, salesmen, crop scouts, harvesters and possibly beekeepers) • Movement of plant material and growing media/soil from controlled and restricted areas
Phase 5	Surveillance of production and retail nurseries, gardens and public land where plants known to be hosts of the pest are being grown
Phase 6	Agreed area freedom maintenance, post control and containment

3.5.3 Post-eradication surveillance

The period of pest freedom sufficient to indicate that eradication of the pest has been achieved will be determined by a number of factors, including cropping conditions, the previous level of infestation, the control measures applied and the pest biology.

Specific methods to confirm eradication of Turnip moth may include:

- Monitoring of sentinel plants that have been grown at the affected sites. Plants are to be monitored for symptoms or other indications of Turnip moth presence
- If symptoms or suspect insects are detected, samples are to be collected and stored and plants destroyed
- Targeted surveys for Turnip moth should be considered within the Quarantine Zone to demonstrate pest absence for a period of up to 12 months after eradication has been achieved

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5 Appendices

Appendix 1. Standard diagnostic protocols

Identification of Agrotis segetum Denis & Schiffermüller

Figures *Figure 4 Wing structure*Figure 14 **Caterpillar** have been included to help with identification. More comprehensive identification material is presented in the Pest Risk Review for Turnip Moth. This includes a detailed description of the major identification features and the differences between *Agrotis segetum* and other *Agrotis* species. The Pest Risk Review also contains many pictures showing the identification features and differences between these species.

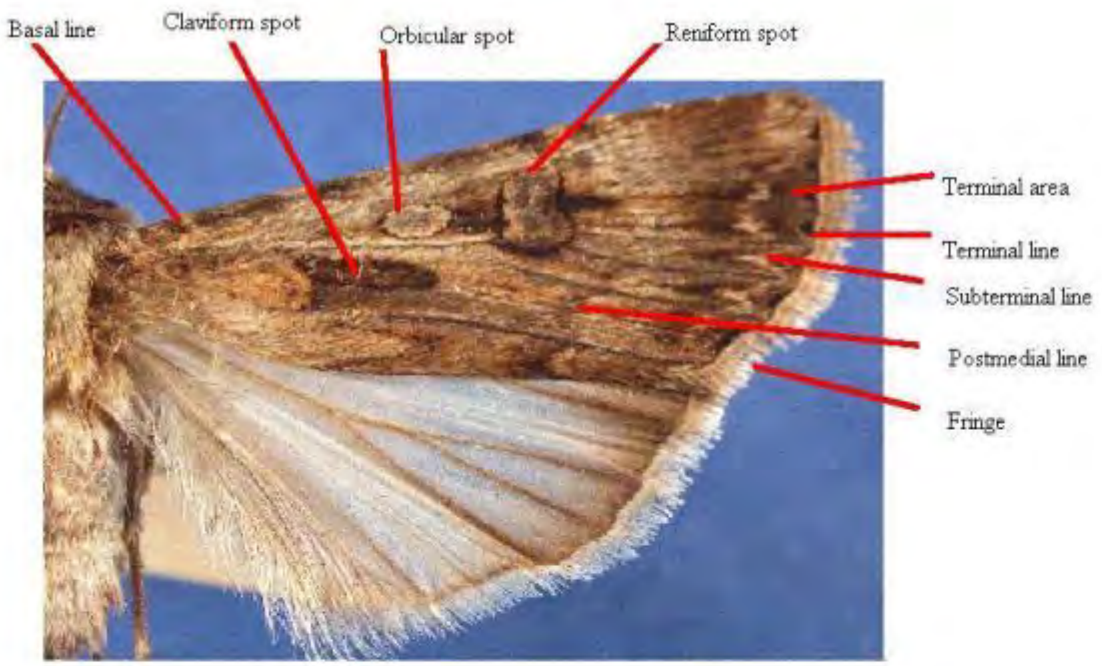

Figure 4 *Wing structure*

Figure 5 *Male dorsal*

Figure 6 *Male ventral*

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Figure 7 *•Wingspan approximately 38-45 mm*

Figure 8 *Forewing markings of circle and kidney*

Figure 9 *Wing veins thin dark-brown lines*

Figure 10 Hindwings grey in female

***Figure 11** Hindwings white/silver in male*

Figure 12 *antennae thread-like in female*

Figure 13 *Antennae slightly feather-shaped in male*

Figure 14 *Caterpillar*

Appendix 2. Experts, resources and facilities

There are few taxonomic experts in Australia of the very large family Noctuidae (approximately 1990 species described in Australia to date). Entomologists with a particular interest in the taxonomy of the family in Australia include Mr L. Hill (Department of Primary Industries, Tasmania) and M. Matthews . The only person to have published taxonomic papers on Australian representatives of the genus *Agrotis* in the last 50 years is Dr I.F.B. Common (e.g., Common 1958). Expert taxonomists of Lepidoptera would be capable of identifying *A. segetum* to species level, especially if comparable specimens were available. Unfortunately only Dr M. Horak (ANIC, CSIRO Entomology) is the only full time Lepidoptera taxonomist in Australia.

For species level identification, Fiebiger (1990, 1997) publications should be used. Identifications to species level is made easier for general entomologists with the freely available PaDil website **http://www.padil.gov.au**/ and comparable, pin-mounted specimens or photographs of wing characteristics, as presented in Appendix 1 of the Pest Risk Review.

Expert	State	Details
Mr L. Hill	Tasmania	Department of Primary Industries
Dr M. Horak	ACT	ANIC, CSIRO Entomology

Other competent entomologists are likely to reside in state department laboratories or within private industry. Included in Table 3 is a list of diagnostic facilities that may be of help for identifying unknown specimens.

Table 3 *Diagnostic service facilities in Australia*

Facility	State	Details
DPI Victoria – Knoxfield Centre	Vic	621 Burwood Highway Knoxfield VIC 3684 Ph: (03) 9210 9222; Fax: (03) 9800 3521
DPI Victoria – Horsham Centre	Vic	Natimuk Rd Horsham VIC 3400 Ph: (03) 5362 2111; Fax: (03) 5362 2187
NSW DPI Diagnostic and Analytical Services (DAS) – Elizabeth Macarthur Agricultural Institute	NSW	Woodbridge Road Menangle NSW 2568 PMB 8 Camden NSW 2570 Ph: (02) 4640 6327; Fax: (02) 4640 6428
NSW DPI Diagnostic and Analytical Services (DAS) – Orange Agricultural Institute	NSW	1447 Forest Rd Locked Bag 6006 ORANGE NSW 2800 Ph: (02) 6391 3980 ; Fax: (02) 6391 3899
NSW DPI – Tamworth Agricultural Institute	NSW	4 Marsden Park Road Calala NSW 2340 Ph: (02) 6763 1100; Fax: (02) 6763 1222
NSW DPI – Wagga Wagga Agricultural Institute	NSW	PMB Wagga Wagga NSW 2650 Ph: (02) 6938 1999; Fax: (02) 6938 1809
SARDI Plant Research Centre – Waite Main Building, Waite Research Precinct	SA	Hartley Grove Urrbrae SA 5064 Ph: (08) 8303 9400; Fax: (08) 8303 9403
Grow Help Australia	QLD	Entomology Building 80 Meiers Road Indooroopilly QLD 4068 Ph: (07) 3896 9668; Fax: (07) 3896 9446
Department of Agriculture and Food, Western Australia (AGWEST) Plant Laboratories	WA	3 Baron-Hay Court South Perth WA 6151 Ph: (08) 9368 3721; Fax: (08) 9474 2658

Appendix 3. Communications strategy

A general Communications Strategy is provided in PLANTPLAN

Appendix 4. Market access impacts

A search of AQIS PHYTO (**http://www.aqis.gov.au/phyto/asp/ex_search.asp**) database online yields no results concerning market access for any commodity or country, however a more detailed enquiry is warranted.