Ministry for Primary Industries
Manatū Ahu Matua

The likelihood of establishment of Brown marmorated stink bug in the New Zealand autumn/winter period

MPI Technical advice

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Growing and Protecting New Zealand

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1 Purpose

The purpose of this paper is to provide information on the likelihood of establishment of Brown marmorated stink bug (*Halyomorpha halys*, BMSB) during the New Zealand autumn/winter period. This advice will be used to decide whether the treatment period for vehicles and machinery from the USA can be reduced.

2 Background

Currently all vehicles and machinery from the USA require year-round treatment to mitigate the likelihood of establishment of BMSB via that importation pathway. The current treatment requirement was implemented as an urgent measure in December 2014 in response to finding aggregations of BMSB on vehicles. MPI is subsequently reviewing whether treatment is technically justified as a year-round requirement on vehicles and machinery from the USA.

3 Summary of review findings

Overall the likelihood that BMSB will establish in New Zealand during the autumn/winter period (the beginning of May to the end of August) is so low as to be considered negligible. The likelihood of establishment has been determined by consideration of these factors:

- Propagule pressure is low: very few bugs have ever been intercepted in either New Zealand or Australia during the northern hemisphere spring and summer period (May to August), as the active feeding behaviour of BMSB at this time limits their association with the vehicle and machinery pathway.
- Biological data about reproductive diapause and environmental cues means that US spring/summer BMSB arriving in New Zealand are unlikely to re-enter diapause on encountering New Zealand’s autumn or winter conditions.
- Biological data about temperature thresholds and environmental cues means that there is a moderate likelihood that some BSMB may be able to survive in a state of post-diapause quiescence through the New Zealand winter and into the period when suitable conditions occur for reproduction in the spring and summer.
- Biological data about developmental thresholds and reproductive cues means that there is a low likelihood that egg laying and subsequent survival and development of offspring will result from gravid females entering New Zealand during the autumn/winter period providing they encounter a protected microclimate.
- Establishment will rely on multiple individuals arriving together, surviving, and remaining in proximity. Given the low numbers arriving during this period establishment of a population resulting from BMSB arriving during the New Zealand autumn/winter period is negligible.

4 Analysis of the likelihood of establishment of Brown marmorated stink bug in New Zealand

4.1 BACKGROUND

Overwintering aggregations of Brown marmorated stink bug (*Halyomorpha halys*, BMSB) have been intercepted at the New Zealand border on inanimate items such as vehicles and within shipping containers. New Zealand and Australian interception records indicate that the majority of BMSB arrive on inanimate items during the northern hemisphere autumn and winter period (September to April). Around half the New Zealand interceptions during this period are of single individuals; however, in some instances up to 36 BMSB have been found on a single commodity. All intercepted BMSB are dissected to determine the reproductive status. No BMSB intercepted in New Zealand were sexually mature.

Very few BMSB have ever been intercepted in either New Zealand or Australia during the northern hemisphere spring and summer period (May to August)[1]. In New Zealand only two individuals have been intercepted during this period. These were adult females and neither of them showed any egg development on dissection.

The likelihood of establishment of BMSB increases as the number of bugs arriving in New Zealand increases. Additionally, establishment is much more likely from aggregations that arrive on a single pathway at the same time, than from individual BMSB arriving at different times. While studies from the USA indicate that a population can establish from a founder population consisting of very few individuals (Xu *et al.* 2013) these individuals would need to arrive on the same pathway at the same time, and then remain in proximity to each other for mate finding and subsequent establishment to occur.

When compared with the container pathway, the vehicle pathway is a low volume pathway. Between 60,000 and 80,000 containers are imported from the USA every year and around 720 truck and 6,000 cars are imported annually from the USA (data from MPI internal database). All containers are directed to transitional facilities for inspection prior to unloading, as pre-shipping treatment is not possible for most containers. Figures 1 and 2 show the breakdown by month of new and used vehicles imported from the USA in 2014.

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[1] See appendix one for a summary of recent interceptions

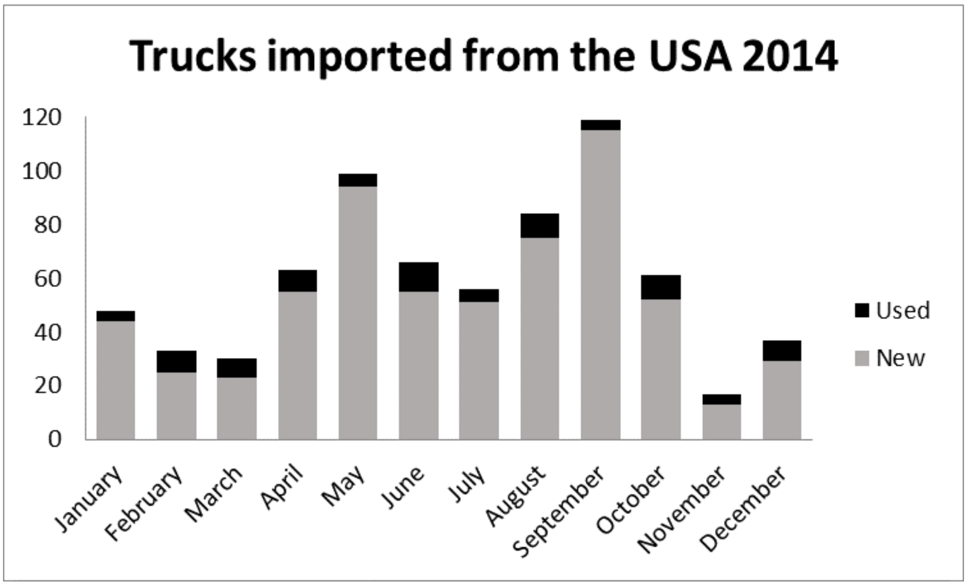

Figure 1. New and used trucks imported from the USA monthly in 2014

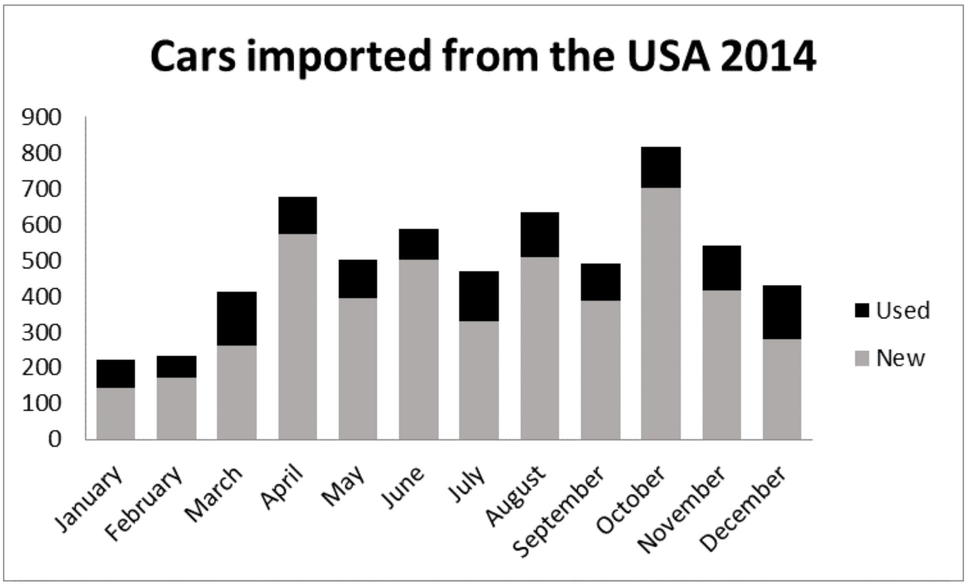

Figure 2. New and used cars imported from the USA monthly in 2014

The likelihood of establishment of BMSB in New Zealand from overwintering populations is high. This is because these bugs arrive in aggregated adult populations, and on arrival in New Zealand, will encounter the environmental conditions (warmer temperatures and longer day lengths) that signal the end of diapause and initiate reproductive maturation (Niva and Takeda 2003). The production of an aggregation pheromone serves to keep the population in close proximity (Weber *et al.* 2014) therefore mate finding is likely.

The minimum temperature at which ovarian development occurs is 16.3°C, and most females reach sexual maturity within two weeks of emergence from overwintering (Lee *et al.* 2013; Nielsen 2008). The minimum temperature for development of all life stages is reported to be between 11 and 14.7°C; at these temperatures between 630 and 537 degree days are required to complete development from egg through to adult (Lee *et al.* 2013; Nielsen 2008). This means that BMSB arriving into Auckland (the port of arrival for most USA cargo) in December when the temperature averages 17.7°C will be able to mature sexually and reproduce with the first generation reaching adulthood in either February (with a minimum developmental threshold of 11°C; see Table 1) or April (with a minimum developmental threshold of 14.7°C; see Table 2).

Table 1. Accumulated degree days for Auckland at a minimum threshold of 11°C.
The number of accumulated degree days required at this temperature is 630

Month	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Ave daily max[2]	21.60	23.13	23.68	22.43	20.10	17.73	15.54	14.66	15.06	16.51	17.83	19.49
Ave daily min	13.99	15.16	15.78	14.40	12.12	10.30	8.08	7.05	7.54	8.92	10.44	12.00
(max+min)/2	17.79	19.15	19.73	18.42	16.11	14.01	11.81	10.86	11.30	12.72	14.13	15.74
minus lower threshold (11°C)[3]	6.79	8.15	8.73	7.42	5.11	3.01	0.81	-0.14	0.30	1.72	3.13	4.74
times 30 (to account for days)	203.72	244.44	261.91	222.54	153.32	90.43	24.29	-4.29	9.05	51.54	94.00	142.33
Accumulated degree days	203.72	448.16	710.07	932.61	Degree days reached for this temperature							

Table 2. Accumulated degree days for Auckland at a minimum threshold of 14.7°C.
The number of accumulated degree days required at this temperature is 537

Month	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Ave daily max	21.60	23.13	23.68	22.43	20.10	17.73	15.54	14.66	15.06	16.51	17.83	19.49
Ave daily min	13.99	15.16	15.78	14.40	12.12	10.30	8.08	7.05	7.54	8.92	10.44	12.00
(max+min)/2	17.79	19.15	19.73	18.42	16.11	14.01	11.81	10.86	11.30	12.72	14.13	15.74
minus lower threshold (14.7°C)	3.09	4.45	5.03	3.72	1.41	-0.69	-2.89	-3.84	-3.40	-1.98	-0.57	1.04
times 30 (to account for days)	92.72	133.44	150.91	111.54	42.32	-20.57	-86.71	-115.29	-101.95	-59.46	-17.00	31.33
Accumulated degree days	92.72	226.16	377.07	488.61	530.93	Degree days reached for this temperature						

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[2] Temperature data for this and subsequent tables from https://www.niwa.co.nz/education-and-training/schools/resources/climate

[3] Degree day calculations for this and subsequent tables from https://ipm.illinois.edu/degreedays/calculation.html

4.2 ANALYSIS

The analysis below assesses the likelihood of establishment of a BMSB population resulting from adult BMSB arriving in New Zealand during the New Zealand autumn and winter period (May 1 to August 31) on the vehicle and machinery pathway. Nymphs are much less mobile than adults, lack the ability to fly, and remain feeding within individual host plants, they are therefore not considered a risk on the vehicle and machinery pathway. Egg masses are laid on the undersides of leaves (Nielsen *et al.* 2008) and are also not a risk on the vehicle and machinery pathway. The risks of nymphs and egg masses on other pathways has been assessed in the all pathways risk assessment[4].

It is important to note that while there are some studies documenting overwintering cues and overwintering survivorship of BMSB, these studies typically look at BSMB entering an overwintering state at the beginning of autumn. While these papers only examine BMSB under typical conditions, useful information can be extrapolated from these studies to try and predict how BMSB will respond in the unusual situation of suddenly encountering overwintering cues (due to arriving into the New Zealand winter) in the middle of summer. Evidence has been taken from studies of diapause in other species of Pentatomidae; however, diapause has been studied in less than 1% of the known species of stink bugs (Saulich and Musolin 2012) and therefore any information extrapolated from these studies should be interpreted with caution.

There are three potential scenarios for establishment:

1. Adults arriving into New Zealand autumn/winter are able to enter diapause;
2. Adults do not enter diapause but are able to survive through the New Zealand autumn/winter and reproduce the following spring/summer;
3. Reproductively mature adults entering New Zealand during the autumn or winter period are able to reproduce and the offspring are able to survive.

These scenarios will be considered in turn below.

4.2.1 Scenario 1: Adults arriving into New Zealand autumn/winter are able to enter diapause

This section assesses the likelihood of spring/summer BMSB arriving in New Zealand entering diapause on encountering autumn or winter conditions.

BMSB that arrive in New Zealand between the beginning of May and the end of August have arrived from spring and summertime conditions in the northern hemisphere and are actively feeding at this time. Given that the cues for diapause are thought to be driven by day length, possibly combined with a reduction in temperature (Lee *et al.* 2013), conditions in New Zealand at this time will signal diapause.

Ovarian degeneration and reproductive diapause begins in early to mid-August (late summer in the northern hemisphere), initiated by decreasing day length (Niva and Takeda 2003). Reproductive diapause has been characterized by the presence of undeveloped eggs in females and unapparent sperm tubes in males (Lee *et al.* 2013; Niva and Takeda 2003).

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[4] http://www.biosecurity.govt.nz/files/regs/imports/risk/risk-analysis-halyomorpha-halys.pdf

There is some disagreement in the literature as to whether the cues signalling diapause are cumulative and required during both the nymphal and adult stages (Lee *et al.* 2013; Niva and Takeda 2003), or whether only the adult is responsive to day length cues (Haye *et al.* 2014).

Niva and Takeda (2003) exposed BMSB to low temperature and short days during the adult stage only and found that this resulted in a smaller percentage diapause than when late nymphal stages onwards were exposed to the same conditions. When BMSB were exposed to diapause inducing conditions in the late nymphal stages, between 80 and 100% of adults entered diapause; however, when BMSB were only exposed in the adult stages 27% of adults entered reproductive diapause as determined by dissections (Niva and Takeda 2003).

Haye *et al.* (2014) were able to induce nymphs to develop into reproductive adults when removed from short day conditions and reared in long day conditions. They concluded that only adults seem to be responsive to diapause cues. Additionally they found that newly emerged adults reared in low temperature outdoor conditions (mean temperatures between 15.3 and 16.6 °C) did not show any mating or oviposition behaviour.

If adult BMSB were to arrive in New Zealand from the beginning of autumn they may not have had day-length signals that would induce diapause, assuming these cues are cumulative; however, on arrival they will also lack the temperature and day length cues that signal mating and oviposition behaviour. If however, the cues are only required in the adult stage and these summer adults are able to enter diapause they are likely to lack sufficient lipid content to sustain them in diapause (Lee *et al.* 2013), as this body condition is built up over the active feeding period (Niva and Takeda 2003).

There is evidence from other Pentatomids that post-diapause reproductive adults cannot switch to diapause in response to short-day stimuli (e.g. *Nezara viridula* (green vegetable bug) Musolin 2012). If this is the case for BMSB then any reproductive adult, having emerged from diapause in the US, would be unable to re-enter diapause on encountering the short day conditions of the New Zealand autumn/winter period.

There is a low likelihood that spring/summer BMSB arriving in New Zealand will either enter diapause or survive diapause on encountering autumn or winter conditions.

4.2.2 Scenario 2: Individuals are able to survive through the New Zealand autumn/winter and reproduce the following spring/summer

This section assesses the likelihood of adult BSMB surviving through the New Zealand winter until suitable conditions for reproduction in the summer.

Diapause consists of three states; pre-diapause, diapause and post-diapause quiescence. This reflects the fact that diapause is not only a specific physiological state but also a dynamic process whose ending is followed by resumption of activity (Saulich and Musolin 2012).

In pre-diapause, direct development continues but the individual responds to specific environmental cues and becomes destined for entry into the diapause phase where direct development does not occur. These cues signal the advent of deterioration of environmental conditions and the sensitive period of individuals is genetically determined (Koštál 2006).

Diapause itself is a dynamic process and consists of an initiation phase, maintenance, and termination (Koštál 2006). In BSMB reproductive diapause is initiated by decreasing day length (Niva and Takeda 2003). During these stages of diapause there is no direct development. In the initiation phase metabolism is suppressed and the individual seeks suitable microhabitats. In the maintenance phase the metabolic rate is low and constant; however, there is a gradual decrease of intensity and an increase in sensitivity to cues which signal the end of diapause. The termination phase is signalled by specific changes in environmental conditions, and at the end of this phase direct development may resume if conditions are favourable (Košťál 2006). Termination of diapause in BMSB is driven by increasing day length (Rice *et al.* 2014).

Environmental cues signalling diapause termination may differ from those conditions which are suitable for resumption of direct development. If this is the case the organism remains in a state of post-diapause quiescence (Košťál 2006; Morris 1989). Studies of various species from northern hemisphere temperate climates have shown that in most of them diapause ends in December and the most severe period of winter is spent in the state of post-diapause quiescence (Saulich and Musolin 2012).

Given information about diapause termination from other Pentatomids, BMSB may have an extended period of post-diapause quiescence. BSMB exhibits staggered emergence from overwintering and it can take several months for populations to leave the overwintering site (Lee *at al.* 2013). Emergence typically begins in April in Pennsylvania and the majority of the population will have left the overwintering site by the end of April; however, sometimes in June there are still inactive BMSB in overwintering sites (T. Leskey *pers. comm.* to C. Duthie Sept 2014). Emergence from overwintering sites is likely induced by high temperatures and the exhaustion of resources (Lee *at al.* 2013).

If adults still in post-diapause quiescence were to enter New Zealand during this period (April to June) it may be possible for them to remain in quiescence for the duration of the New Zealand winter in response to the decreased day length and low temperatures during this period.

Establishment is much more likely from aggregations that arrive on a single pathway at the same time, than from individual BMSB arriving at different times. Any individuals arriving during the New Zealand winter period would need to arrive on the same pathway at the same time, and then remain in proximity to each other for mate finding and subsequent establishment to occur. While it is possible that some individuals will remain associated with the vehicle and machinery pathway in a state of post-diapause quiescence after the high risk period of September to the end of April, the majority of the population will have emerged after this time. Given that very few BMSB have ever been intercepted in either New Zealand or Australia during the northern hemisphere spring and summer period (May to August), and the active feeding behaviour of BMSB at this time limits their association with the vehicle and machinery pathway, there is considered to be a low likelihood of sufficient numbers of individuals arriving for population establishment to occur as a result of individuals arriving on this pathway during this period.

It is unknown whether BMSB that have emerged from overwintering sites and are no longer in post-diapause quiescence, but are actively feeding, would be able to re-enter this phase of quiescence and survive the New Zealand winter period. Body size, feeding frequency, developmental rate and lipid accumulation at the nymphal stage of BMSB are under photoperiodic control (Niva and Takeda 2003). In short day conditions such as those of the New Zealand autumn and winter, feeding activity is suppressed (Niva and Takeda 2003) and consequently survival may be reduced due to depletion of resources. Lipid content of adults is a measure of the nutritional status that allows survival over winter. In adults that are actively feeding in the long day conditions of summer the lipid content is half that of adults preparing to diapause at the end of summer, (Lee *et al.* 2013; Niva and Takeda 2003).

Actively feeding BMSB that arrive in New Zealand during the autumn and winter period (May through to the end of August) will encounter short days and low temperatures, additionally the range of suitable feeding structures (ripe fruit) on host plants will be less abundant. BMSB has a preference for mature fruits and needs a variety of species in order to meet the nutritional needs of development and reproduction (Martinson *et al.* 2015).

In addition to depletion of resources through reduced feeding, low temperatures significantly impact development rates and stage specific mortality. Nielsen *et al.* (2008) measured developmental time and survivorship at a range of temperatures. At a constant 17°C, considerably warmer than the average temperatures in New Zealand during the autumn and winter period, development time from egg though to adult was an average of 122 days; however, there was 97% mortality.

Nezara viridula also has photoperiod induced reproductive diapause throughout most of its range; however, in some lower latitudes it is considered that this species does not enter diapause but switches to alternative host plants, and eventually reproduces during the mild winter. It is possible that this species has the potential to respond to change through phenotypic plasticity or rapid evolutionary responses (Musolin 2012). It is possible that BMSB may exhibit the same plasticity; however, it is unknown whether this is a genetic change requiring establishment and subsequent selection pressures or change that may occur in a new founding population.

There is a moderate likelihood of survival of BMSB through the New Zealand winter until suitable conditions occur for reproduction in the summer. However, establishment will rely on multiple individuals arriving together, surviving, and remaining in proximity.

4.2.3 Scenario 3: Reproductively mature adults entering New Zealand in the autumn or winter are able to reproduce and the offspring are able to survive.

This section assesses the likelihood of survival and development of offspring resulting from the arrival of gravid females.

Reproduction in adults is controlled by photoperiod, temperature, and diet (Lee *et al.* 2013; Niva and Takeda 2003). Developmental periods and/or survivorship vary with temperature, at low temperatures the developmental period is longer and mortality is greater (Lee *et al.* 2013). Additionally, the majority of BMSB become inactive below 9°C (Lee *et al.* 2013) and short day conditions supress feeding activity (Niva and Takeda 2003).

Oviposition of BMSB females is stimulated by temperature. There is a requirement for temperatures to continuously increase and to exceed 15°C. This oviposition behaviour is well adapted to the temperature requirements of eggs and first instar nymphs, which develop poorly at the lower developmental threshold of 15°C (Haye *et al.* 2014). It is unknown what role photoperiod plays in oviposition as all studies of fecundity have reared BMSB under long day conditions. Given that ovarian degeneration occurs as a result of short day conditions (Niva and Takeda 2003) it is assumed that day length is a signal for egg laying and that no eggs will be laid under the short day conditions of the New Zealand autumn/winter period.

There is some variation in the literature as to the minimum developmental thresholds and degree day requirements (e.g. Haye *et al.* 2014; Lee *et al.* 2013; Nielsen 2008, see list below); however, there is general agreement from laboratory studies that the lower threshold for egg hatch is 15°C (e.g. Haye *et al.* 2014; Nielsen 2008). In a study by Nielsen *et al.* (2008) 50% mortality of eggs occurred at 15°C and there was 100% mortality of nymphs.

Minimum developmental temperature and required degree days to develop from egg to adult:

11.0°C	630 degree days	Within Lee *et al.* 2013
11.7°C	580 degree days	Within Lee *et al.* 2013
11.9°C	648 degree days	Within Lee *et al.* 2013

12.1°C	649 degree days	Within Lee *et al.* 2013
12.1°C	598 degree days	Within Lee *et al.* 2013
12.2°C	588 degree days	Haye *et al.* 2014
12.9°C	625 degree days	Within Lee *et al.* 2013
13.9°C	471 degree days	Within Lee *et al.* 2013
14.7°C	537 degree days	Nielsen 2008

The number of degree days for development completion (egg to adult) is estimated to be between 630 at a lower threshold of 11°C (Table 3) and 537 at a lower threshold of 14.7°C (Table 4). Assuming entry to New Zealand of a gravid female in May (the beginning of autumn) in Kaitaia (Northland), the warmest location in the country, there is no opportunity to accumulate sufficient degree days for development to the adult stage even if eggs were to be deposited and subsequently hatch. Additionally there is likely to be high egg and nymph mortality at these temperatures.

The temperatures used in the above calculations were taken from meteorological stations and may not best represent the different microclimates within the environment. There may be a marked increase in temperature in sheltered locations depending on surrounding structures and the architecture of specific host plants (e.g. Kean *et al.* 2004). This increase in temperature may increase the development rate and as such it may be possible for complete development through to the adult stage to occur during the New Zealand winter period in some warm locations. However, as with previous scenarios, establishment of a population will rely on multiple individuals arriving together, surviving, and remaining in proximity. Current interception data indicates that there is insufficient propagule pressure necessary for this to happen

There is a low likelihood of survival and development of offspring resulting from gravid females entering New Zealand during the autumn/winter period providing they encounter a protected microclimate. However, establishment will rely on multiple individuals arriving together, surviving, and remaining in proximity

Table 3. Accumulated degree days for Kaitaia at a minimum threshold of 11°C.
The number of accumulated degree days required at this temperature is 630

Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ave daily max	23.92	24.57	23.04	20.94	18.53	16.40	15.61	15.77	17.05	18.13	19.73	21.93
Ave daily min	15.12	15.48	14.23	12.98	11.13	9.22	8.50	8.60	9.67	10.78	11.95	13.78
(max+min)/2	19.52	20.03	18.64	16.96	14.83	12.81	12.06	12.19	13.36	14.46	15.84	17.86
minus lower threshold (11°C)	8.52	9.03	7.64	5.96	3.83	1.81	1.06	1.19	2.36	3.46	4.84	6.86
times 30 (to account for days)	255.72	270.76	229.08	178.92	114.92	54.23	31.67	35.60	70.67	103.67	145.10	205.79
Accumulated degree days					293.84	348.07	85.90	121.50	106.27	209.94	248.77	454.56

Table 4. Accumulated degree days for Kaitaia at a minimum threshold of 14.7°C. The number of accumulated degree days required at this temperature is 537

Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ave daily max	23.92	24.57	23.04	20.94	18.53	16.40	15.61	15.77	17.05	18.13	19.73	21.93
Ave daily min	15.12	15.48	14.23	12.98	11.13	9.22	8.50	8.60	9.67	10.78	11.95	13.78
(max+min)/2	19.52	20.03	18.64	16.96	14.83	12.81	12.06	12.19	13.36	14.46	15.84	17.86
minus lower threshold (14.7°C)	4.82	5.33	3.94	2.26	0.13	-1.89	-2.64	-2.51	-1.34	-0.24	1.14	3.16
times 30 (to account for days)	144.72	159.76	118.08	67.92	3.92	-56.77	-79.33	-75.40	-40.33	-7.33	34.10	94.79
Accumulated degree days					71.84	15.07	0	0	0	0	26.77	121.56

4.3 CONCLUSION

Overall the likelihood that BMSB will establish in New Zealand during the autumn/winter period (the beginning of May to the end of August) is so low as to be considered negligible. The likelihood of establishment has been determined by consideration of these factors:

- Propagule pressure is low: very few bugs have ever been intercepted in either New Zealand or Australia during the northern hemisphere spring and summer period (May to August), as the active feeding behaviour of BMSB at this time limits their association with the vehicle and machinery pathway.
- Biological data about reproductive diapause and environmental cues means that US spring/summer BMSB arriving in New Zealand are unlikely to re-enter diapause on encountering New Zealand's autumn or winter conditions.
- Biological data about temperature thresholds and environmental cues means that there is a moderate likelihood that some BSMB may be able to survive in a state of post-diapause quiescence through the New Zealand winter and into the period when suitable conditions occur for reproduction in the spring and summer.
- Biological data about developmental thresholds and reproductive cues means that there is a low likelihood that egg laying and subsequent survival and development of offspring will result from gravid females entering New Zealand during the autumn/winter period providing they encounter a protected microclimate.
- Establishment will rely on multiple individuals arriving together, surviving, and remaining in proximity. Given the low numbers arriving during this period establishment of a population resulting from BMSB arriving during the New Zealand autumn/winter period is negligible.

4.4 REVIEWERS

- Dr. Anna Rathe - Adviser - Plants and Environment Response
- Dr. Claire McDonald - Adviser - Plants and Pathways Risk Analysis
- Nicky Fitzgibbon - Adviser - Plants and Pathways Risk Analysis – Emerging risks
- Ken Glassey - Senior Adviser - Biosecurity and Environment
- Dr. Sarah Clark - Senior Adviser - Plants and Pathways Risk Analysis
- Dr. Thomas Kuhar – Professor – Department of Entomology, Virginia Tech (USA)

4.5 REFERENCES

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5 Appendix one – recent interception data for New Zealand and Australia

Organisms intercepted on imported goods at the border or post border are periodically identified and recorded during the biosecurity clearance process or as part of a monitoring survey. These records are extremely valuable because they identify residual risk at the border.

There are limitations on interpretation of this information, and these records cannot be used to derive a quantitative picture of the incoming pest load.

Detection is ad hoc for a variety of reasons, and in the absence of structured sampling, statistically reliable estimates of numbers are not possible. Therefore, it is hard to predict the relative significance of different entry pathways. In spite of this, detections have enabled areas of particularly high risk to be identified. Beyond this, these data must not be used for any quantitative analysis without applying a robust procedure which accounts for their qualitative origins. For these reasons and because recording procedures differ between New Zealand and Australia the data presented below does not include counts.

Lines in grey indicate those interceptions that were outside of the northern hemisphere overwintering period for BMSB. This period runs from 1 September to 30 April.

Recent New Zealand interception data

Date	Pathway	Origin	Source
2012 - 2013 Risk Season			
Sep-12	Mail	USA	Post Border
Nov-12	Mail	USA	Post Border
Nov-12	Sea container	USA	Post Border
Jan-13	Sea container	USA	Border
Jan-13	Passenger baggage	Unknown	Post Border
Mar-13	Sea container	USA	Border
Mar-13	Personal effects	USA	Border
Mar-13	Personal effects	China	Border
Mar-13	Motorcycles in container	USA	Border
June 13	**Sea container**	**USA**	**Border**
2013 - 2014 Risk Season			
Oct-13	Sea container	USA	Border
Nov-13	Sea container	USA	Border
Nov-13	Sea container	USA	Border
Nov-13	Vessel	USA	Border
Dec-13	New tractors in container	South Korea	Border
Dec-13	Car Parts	Japan	Border
Jan-14	Car Parts	Japan	Border
Mar-14	Sea container	China	Border
Mar-14	Used vehicle	Unknown	Border
Mar-14	Sea container	USA	Border
Apr-14	Passenger baggage	USA	Border
2014 - 2015 Risk Season			
Sep-14	Vessel	Unknown	Border
Oct-14	eBay parcel containing Dolls	USA	Post Border
Nov-14	eBay parcel containing model train	USA	Post Border
Nov-14	Crane Parts	Italy	Post Border

Nov-14	New vehicle	USA	Post Border
Dec-14	Used vehicle	USA	Border
Dec-14	Used vehicle	USA	Post Border
Dec-14	Water Filter	USA	Border
Dec-14	New vehicle	USA	Border
Dec-14	Vessel	Unknown	Border
Jan-15	Used vehicle	USA	Border
Jan-15	Used vehicle	USA	Border
Jan-15	Motorcycles in container	USA	Border
Jan-15	Personal effects	USA	Border
Jan-15	Personal effects	USA	Border
Jan-15	Personal effects	USA	Border
Jan-15	Personal effects	USA	Border
Jan-15	Used vehicle	Japan	Border
Jan-15	New vehicle	USA	Border
Jan-15	New vehicle	USA	Border
Jan-15	Vessel	USA	Border
Jan-15	Used vehicle	Unknown	Border
Jan-15	Sea container	USA	Border
Jan-15	Sawn timber	USA	Border
Jan-15	Sawn timber	USA	Border
Jan-15	Sawn timber	USA	Border
Jan-15	Sawn timber	USA	Border
Jan-15	Sawn timber	USA	Border

Recent Australian interception data

Date	Pathway	Origin	Source
2012 - 2013 Risk Season			
Oct-12	Packaging	United States	Import Clearance
Jan-13	Personal effects	United States	Import Clearance
Jan-13	Vessel	United States	Seaports
Jan-13	Vessel	United States	Import Clearance
Feb-13	Vessel	United States	Import Clearance
Feb-13	Used vehicle	United States	Import Clearance
Apr-13	Personal effects	United States	Airports
Jul-13	**Used vehicle**	**United States**	**Import Clearance**
2013 - 2014 Risk Season			
Oct-13	New machinery	United States	Import Clearance
Oct-13	New machinery	United States	Import Clearance
Nov-13	Used vehicle	United States	Import Clearance
Nov-13	New machinery	United States	Import Clearance
Nov-13	New machinery	United States	Import Clearance
Dec-13	Personal effects	United States	Import Clearance
Dec-13	Personal effects	United States	Import Clearance
Feb-14	Used vehicle	United States	Import Clearance
Feb-14	Vessel	United States	Import Clearance
Mar-14	Vessel	United States	Import Clearance
Apr-14	Used vehicle	United States	Import Clearance
Apr-14	Sea container	United States	Import Clearance
Apr-14	Used vehicle	United States	Import Clearance
Jul-14	**Tyres**	**United States**	**Import Clearance**
2014 -2015 Risk Season			
Oct-14	Personal effects	United States	Import Clearance
Nov-14	New vehicle	United States	Import Clearance

Dec-14	Sea container	United States	Import Clearance
Dec-14	Used vehicle	United States	Import Clearance
Dec-14	New vehicle	United States	Import Clearance
Dec-14	New vehicle	United States	Import Clearance
Dec-14	Used machinery	United States	Import Clearance
Dec-14	New vehicle	United States	Import Clearance
Dec-14	Vessel	United States	Import Clearance
Dec-14	Vessel	United States	Import Clearance
Dec-14	New vehicle	United States	Import Clearance
Dec-14	New vehicle	United States	Import Clearance
Dec-14	New vehicle	United States	Seaports
Dec-14	Vessel	United States	Seaports
Dec-14	Vessel	United States	Import Clearance
Dec-14	Sheet metal	United States	Import Clearance
Dec-14	New vehicle	United States	Import Clearance