RECOMMENDATIONS FOR AERIAL APPLICATION OF FORAY 48B TO CONTROL THE PAINTED APPLE MOTH

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SUMMARY

This report summarises options for targeted aerial spraying of Btk for control of painted apple moth in Auckland. The SpraySafe Manager 2 (SSM2) aerial spray application modelling system was used to:

- Determine the feasibility of using aerial spraying to target narrow riparian areas and gullies for control of the painted apple moth (PAM).
- Calculate swath displacement (the horizontal offset distance between the flight line and the target area) for a range of operational scenarios and weather conditions.
- Characterise on-target deposition and likely drift levels for a worst-case scenario based on operational and weather conditions.

It was concluded that:

1. Aerial application of Btk to control the painted apple moth is relatively straightforward where there are large continuous target areas, but an appropriate swath displacement should be calculated to ensure maximum deposition within the target area.
2. In all but the most favourable conditions large swath displacements are required to target narrow riparian strips. While it is possible to calculate these displacements using SSM2, the irregular geometry of the target areas, as they follow the variable coastline, would make it extremely difficult to apply these recommendations in practice.
3. To minimise the problem of large swath displacements, operational applications should be made with low wind speeds (less that 7 km/hr) and with a droplet spectrum with a volume median diameter (VMD) of around 150 µm. Release height should be 5 m above the target vegetation or as low as is safe. A table of swath displacement distances for combinations of crosswind speed and release height should be provided based on SSM2 simulations. Applications should be made using up to three passes to maximise the likelihood of achieving the correct application rate within the target area. The extent of spray drift will be high, though dosages will be low.
4. Because of the uncertainties around the practicality of this operation (I am unaware of any other operation of this nature being undertaken) a pre-operation field test will be essential to see if the required targeting can be achieved.
5. Dose-response work should be undertaken as soon as possible to evaluate whether using large droplets and dilute Btk would compromise efficacy compared with small droplets and undiluted Btk.

RECOMMENDATIONS FOR AERIAL APPLICATION OF FORAY 48B TO CONTROL THE PAINTED APPLE MOTH

INTRODUCTION

The goal of the work described in this report was to evaluate the feasibility of aerial application of Foray 48B for control of painted apple moth (PAM) in an urban environment. The population biology of PAM and dose-response relationships between PAM and Btk are not considered in this report. The key issue is determining the practicality of achieving specified levels of deposition in target zones with minimum drift levels outside these areas.

Inspection of the spraying sites identified many practical difficulties with the proposed operation. A previous insect pest eradication operation in Auckland (Operation Evergreen) used a blanket spray approach. This technique is relatively straight forward as the successive swaths laid down over a large area ensures good coverage of target vegetation. The likelihood of significant skips (areas receiving low doses of BtK or that are missed completely) is very low.

MAF have specified a different approach for the PAM operation. Narrow riparian strips of vegetation, steep gullies, and a few larger areas are the main target zones. Applications to the larger areas should be relatively straight forward as a blanket spray approach can be used. However, targeting the narrow strips of vegetation and the gullies is much more problematic. The main difficulties are summarised below:

a) The vegetation in the narrow strips is often very tall (up to 30 m?), but the main target species are generally the understorey component (10-15 m tall).

b) There are many obstacles in the spray zones, such as overhead power lines or individual tall trees. To safely avoid these obstacles, spray release heights will often be very high, increasing the drift potential. In some cases, steep terrain coupled with these obstacles makes for even higher spray release heights.

c) Target vegetation along the riparian margins is very variable in terms of its height (1-30 m?) width (10-20 m?) and its linear orientation. This presents a number of practical difficulties, especially determining how to define the relationship between the location of the spray aircraft relative to the target area, in relation to release height, wind speed and wind direction. With small droplets (necessary for coverage) and high release heights, there will be considerable downwind movement of the spray cloud. Therefore, to deposit the spray on a specific strip of vegetation the aircraft must release the spray at a significant upwind distance from the target area - this is termed the swath displacement (i.e. the horizontal offset distance between the flight line and the target area). While this distance can be defined for a given condition, in reality the wind direction relative to the target area and flight line will be constantly changing in relation to the convoluted nature of riparian strips. Therefore accurately targeting these strips or gullies will be a major challenge even under ideal conditions.

As mentioned above, the success of the operation depends on achieving good coverage of Btk on the target foliage. While it is possible to obtain reasonable coverage with medium sized droplets (around 200 μm volume median diameter or VMD) and high spray volumes (20-50 l/ha), evidence suggests that the most efficacious approach is using small droplets produced from undiluted Btk (J. Ray, pers. comm.). The trade-off with this strategy is that using small droplets increases the drift potential.

Objectives of this study were to:

1. Determine the feasibility of targeting narrow riparian areas and gullies for control of the painted apple moth (PAM) by aerial spraying.
2. Calculate swath displacement (the horizontal offset distance between the flight line and the target area) for a range of operational scenarios and weather conditions.
3. Characterise on-target deposition and likely drift levels for a worst-case scenario based on operational and weather conditions.

METHODS

Swath displacement

SpraySafe Manager 2 (SSM2) is a spatially based aerial application simulation model that is run from within the ArcView geographical information system (GIS). SSM2 was used to determine the effect of different operational and weather conditions on the swath displacement required to target a narrow vegetation strip when spraying with a BK117C-1 helicopter. As mentioned above, the swath displacement is the horizontal offset distance, between the flight line and the edge of the target area, with the flight line upwind of the target area (Figure 1). A swath displacement distance is required to ensure that when the swath of spray produced by the aircraft reaches the ground, it hits the target area. Factors having the greatest influence on swath displacement are: droplet size, release height, and crosswind speed.

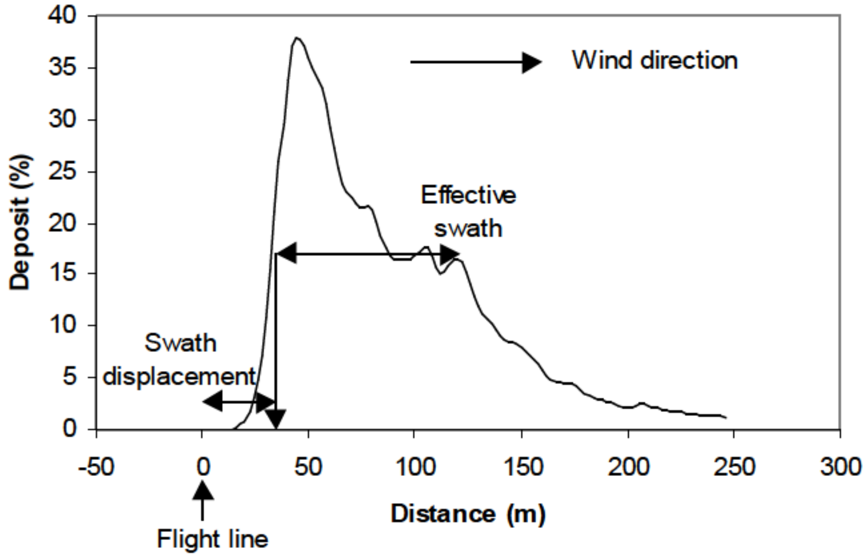

Figure 1: Results from a SpraySafe Manager 2 simulation to illustrate the concept of swath displacement due to a crosswind and other operational factors such as release height, and droplet size (see text for detailed explanation).

There are several steps to calculating swath displacement. First of all, the swath pattern must be produced and then the effective swath is calculated. The effective swath is the distance across the swath pattern from the first point that has a deposition value of 50% of the maximum to the last point that has this same value. In Figure 1, the swath displacement for has been determined as 38 m for an example set of operating and weather conditions. Therefore, to deposit the maximum amount of spray in the target zone, the fight line must be positioned 38 m upwind of the target boundary.

Swath displacement is the combined effect of release height, droplet size and crosswind speed on spray deposition. In general, as droplet size decreases and both wind speed and release height increase, the swath pattern becomes more spread out and the peak deposition value decreases. Therefore the relationship between swath displacement and operational factors is not straightforward.

Swath displacements were determined for a range of SSM2 scenarios (Table 1). A base scenario was defined using a standard set of conditions. Thirty SSM2 simulations were run to calculate swath displacement based on the standard inputs and all combinations of 5 release heights, three crosswind speeds and two droplet sizes. Because droplet spectra for Foray 48B and the appropriate nozzles were not available, other droplet spectra with the required VMD were selected from the SSM2 database.

Table 1: Thirty SSM2 simulations were run to calculate swath offset distances based on the standard inputs and all combinations of 5 release heights, three crosswind speeds and two droplet sizes.

Variable	Standard inputs	Test values
Aircraft type	Bk117-C1	
Release height (m)		10, 20, 30, 40, 50
Spray speed (knots)	60	
Boom width (% of rotor length)	60	
Temperature (°C)	12	
Relative humidity (%)	80	
Crosswind speed (km/hr)		3.6, 7.2, 10.8
Spray material	Foray 48B	
Spray density (g/cm^3)	1.2	
Volatile fraction	0.39	
Active fraction	0.61	
Application rate (Litres/ha)	5	
Atomisers	4xAU5000	
Droplet spectrum VMD[1]		120, 170

[1]Volume median diameter

Spray interception by riparian strips

SSM2 was designed for use in situations where spray applications are made to uniform surfaces e.g. complete forest canopies. The proposed operation for control of PAM is more complicated, especially the targeted spraying of narrow riparian strips. There are two main concerns:

- In a standard SSM2 simulation the spray release height is the vertical distance from the nozzle to the ground surface or the top of the plant canopy where one is present. In the complex PAM situation the assumption of a closed canopy is not valid. An isolated strip of vegetation means that both the height of the aircraft above the ground and the canopy height itself are significant factors. After the spray cloud is released from the aircraft it will drift downwind. Spray particles could be: (a) deposited on the ground before reaching the riparian strip; (b) intercepted by the vegetation strip; pass through the vegetation strip; or (c) be deposited within or beyond the shadowing effect of the strip. **Since SSM2 does not simulate these conditions, modifications to the model were made to try to incorporate relevant factors in a simplified simulation.**

  A worst-case scenario was constructed with a vegetation strip of 30 m height and 20 m width, a 10.8 km/hr crosswind, and a spray release height of 50 m. It was assumed that 70% of spray entering the strip would be deposited on the vegetation.

- Airflow around an obstacle, such as a strip of vegetation, is not simulated in SSM2. However, because the riparian strips are relatively porous (open) it is reasonable to assume that there will not be a strong displacement of air over the top of the strip. If this were the case, many of the particles would be carried over the vegetation and would not be deposited in the target area.

RESULTS AND DISCUSSION

Swath displacement

Swath displacement increases rapidly as both crosswind speed and release height increase (Figure 2). Although not intuitive, swath displacement is higher for the larger droplet size. This effect is related to the higher peak deposition and less spread out swath pattern when using larger droplets. Clearly, the smaller the swath displacement the easier it will be to target discrete, narrow vegetation strips. However, to keep the swath displacement below 100 m, the release height must be less than 30 m in all but the lightest of cross winds. Stronger winds are tolerable where release heights are below 30 m.

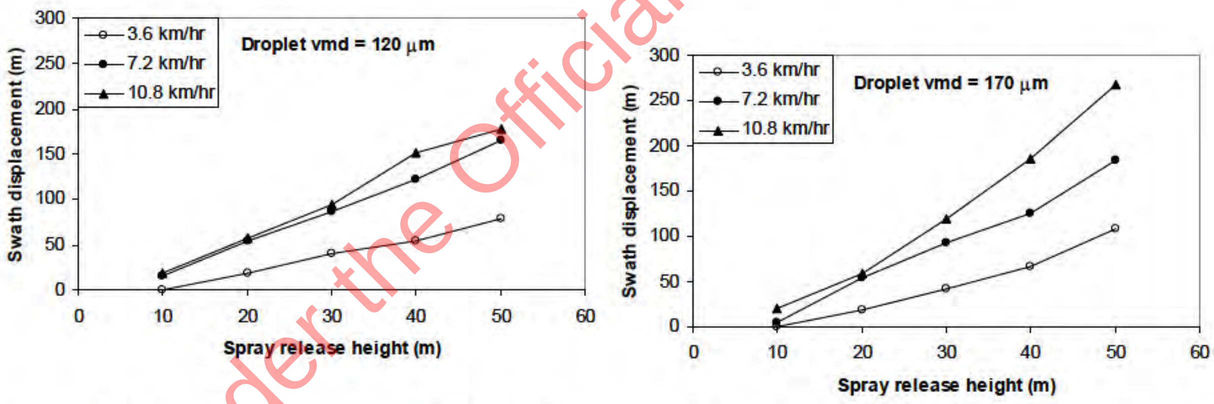

Figure 2: Effect of spray release height and crosswind speed on swath displacements for droplet spectra with VMDs of 120 or 170 μm.

Even with the larger droplet size, the sensitivity of swath displacement to release height and crosswind speed raises a major concern about the practicality of an operation to target a narrow riparian zone. While a general recommendation can be made about an appropriate swath displacement for a given condition, actually spraying according to these instructions will be extremely difficult at best. One key problem is that the coastline is dissected and irregular, so the wind direction relative to the aircraft and the target area will be changing continuously. In addition, release heights will change as the ground contour varies or the pilot has to avoid obstacles. So, although simulations can provide guidelines, ultimately the success of the operation will rely to a large extent on the flying and observational skills of the pilot.

Spray interception by riparian strips

Results of the worst-case scenario simulation (vegetation strip of 30 m height and 20 m width, a 10.8 km/hr crosswind, spray release height of 50 m, 120 µm droplet VMD) indicate an extremely dispersed swath pattern with a low peak deposition at 3.4% of the application rate (Figure 3). In this case, a swath displacement of 178 m would be required to ensure the edge of the effective swath coincides with the edge of the target area.

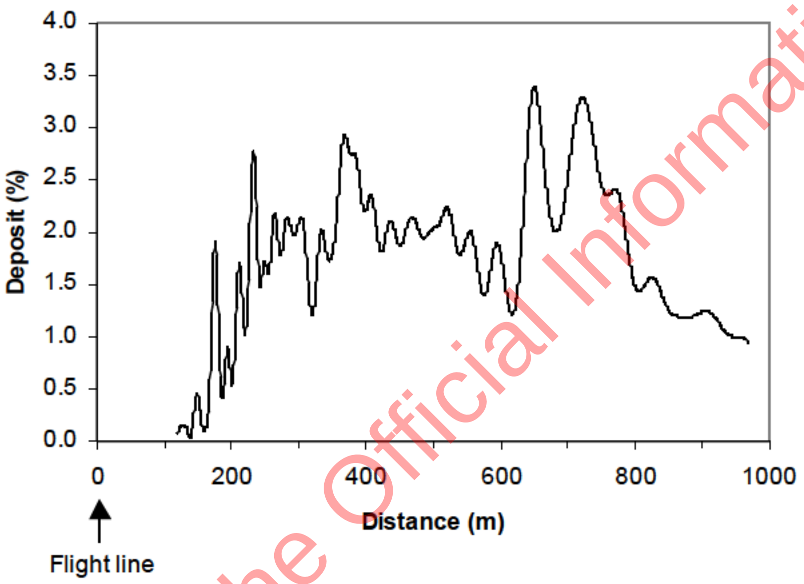

Figure 3: Swath pattern produced under a worst-case scenario situation.

The deposit pattern in Figure 3 is calculated using the assumption that the spray application is made to a "smooth" surface. In reality, a 30 m tall strip of vegetation is located 178 m down wind of the flight line (i.e. swath displacement of 178 m) and this will filter droplets that would otherwise drift further down wind. Results of an attempt to simulate this phenomenon are shown in Figure 4. The flight line is located at the left-hand end of the figure (black and white line), 178 m upwind of the vegetation strip represented by the blue box. The different colours represent deposition levels (in percentage of the application rate). Between the flight line and the vegetation strip, there are only low levels of deposition (<1% of the application rate). The vegetation strip effectively filters out spray droplets and deposition increases up to 25% of the application rate. Downwind of the vegetation there is a shadowing effect and then beyond this, drift levels increase again. Thus there will be high levels of drift beyond the target area even though actual dosages are low.

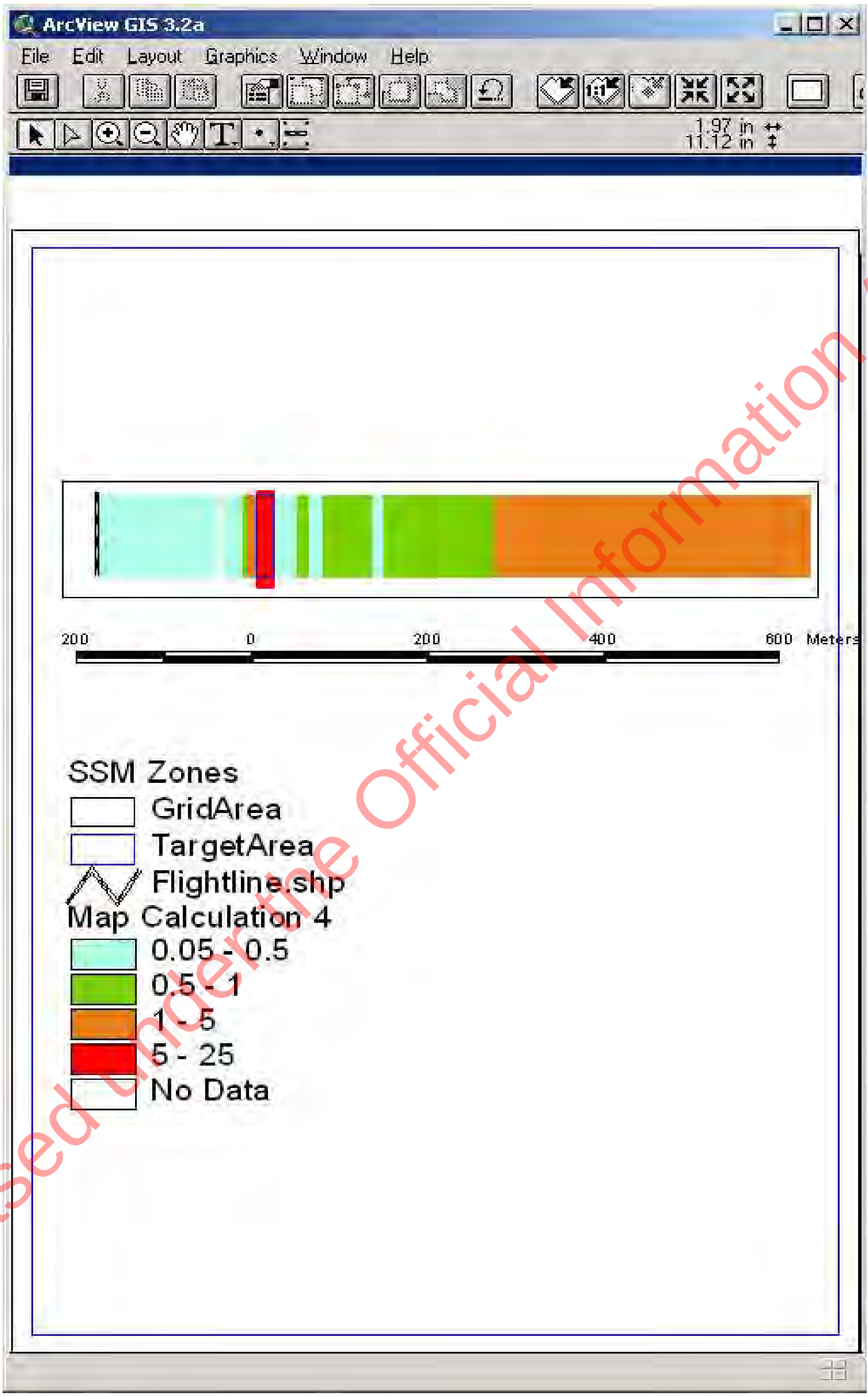

Figure 4: Modified SSM2 simulation to include the effect of a vegetation strip (deposition values are represented by colours and are percentage of the application rate).

Under this worst-case scenario, the swath pattern is so spread out that flying accuracy is not too critical as long as the aircraft is well upwind of the target area. However, the concern is that the application rates are below what is necessary to be confident about achieving control. Therefore the aircraft should make a minimum of three passes, following the same basic flight line, to ensure the target are receives a reasonable dose.

CONCLUSIONS AND RECOMMENDATIONS

1. Aerial application of Btk to control the painted apple moth is relatively straightforward where there are large continuous target areas. However, even in these areas an appropriate swath displacement should be calculated to ensure maximum deposition within the target area.
2. Results of SSM2 simulations indicate that in all but the most favourable conditions large swath displacements are required to target narrow riparian strips. While it is possible to calculate these displacements using SSM2, the irregular geometry of the target areas, as they follow the variable coastline, would make it extremely difficult to apply these recommendations in practice. The wind direction would be constantly changing relative to the aircraft and the target area and so the necessary swath displacement would also be changing. Levels of deposition on narrow strips are likely to be reasonably high because of the filtering effect of vegetation strips, but there will be extensive drift with low dosages.
3. The only ways to simplify the application process, to increase the probability of success are:
   (i) Increase the size of the target area so the application is made to a large continuous block as with the tussock moth operation. Advice from MAF indicates that this is not an acceptable option to the Auckland public / residents in the spray area.
   (ii) Place a severe restriction on acceptable weather conditions. In all situations where flying height is above 15-20 m, wind speeds above about 3.6 km/hr (1 m/s) require large swath displacements. While restricting the acceptable "weather window" will make it easier for pilots to apply appropriate swath, there is a risk that the acceptable conditions occur so infrequently that the spraying cannot be completed on time. An assessment of the frequency and duration of typical weather classes is required to help make a decision on what is reasonable.
   (iii) The only other option is to use larger droplet sizes. The droplet spectrum tested with a VMD of 170 µm was not large enough to produce a large advantage over the 120 µm spectrum. While a spectrum with a VMD of 200-250 microns would make a significant difference, it would severely compromise coverage. To counter this, a higher spray volume

would be required using a more dilute spray mixture. This option cannot be recommended without new dose-response studies that demonstrate efficacy would not be compromised.

Considering the above constraints, the following recommendations are made:

1. Applications should be made with low wind speeds (less that 7 km/hr) and with a droplet spectrum with a VMD of around 150 µm. Release height should be 5 m above the target vegetation or as low as is safe. A table of swath displacement distances for combinations of crosswind speed and release height will be provided based on SSM2 simulations. Applications should be made using up to three passes to maximise the likelihood of achieving the correct application rate within the target area.
2. Because of the uncertainties around the practicality of this operation (I am unaware of any other operation of this nature being undertaken) a pre-operation field test will be essential to see if the required targeting can be achieved.
3. Dose-response work should be undertaken as soon as possible to evaluate whether using large droplets and dilute Btk would compromise efficacy.