PHEROMONE TRAPPING OF ADULT MALE SPRUCE BUDWORM IN THE MANITOBA MODEL FOREST

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Submitted to the
Manitoba Model Forest

BY

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Introduction

The spruce budworm, *Choristoneura fumiferana*, outbreak in eastern Manitoba has persisted for over 20 years. A study in 1991 indicated that the budworm was responsible for a loss of 295,632 m^3 of spruce/fir timber within the Pine Falls Paper Co. Forest Management License area. These losses occurred mainly in the Bird Lake, Wanipigow River and Manigotagan watershed areas. Considerable damage also occurred to prime recreational forested areas within Nopiming Provincial Park.

Within an area to the east of Lake Winnipeg and northeast of the Winnipeg River (Figure 1) there is approximately 14,000 ha of budworm vulnerable forest types. In 1993 the spruce budworm population in this area was at endemic or pre outbreak levels. Conventional sampling methods for predicting defoliation (egg mass and larval surveys) often do not accurately detect spruce budworm densities at endemic population levels. However, recently pheromone traps have been demonstrated to be an effective method of sampling low level populations of spruce budworm (Sanders 1988).

Sexually mature spruce budworm female moths produce sex pheromones (chemicals produced by an individual for the purpose communicating with other individuals of the same species) prior to mating. This pheromone allows receptive males to detect and make contact with the female. Due to species specificity and high potency, sex pheromones have received considerable attention for detecting and monitoring populations (Sanders *et al.* 1995). The sex pheromone of the spruce budworm has been identified (Sanders and Weatherston 1976) and a synthetic pheromone is available for monitoring purposes. A modified version of this synthetic pheromone is now in use for monitoring populations throughout much of the spruce budworm's range in Canada.

In 1994 the Manitoba Model Forest approved funding for pheromone trapping of spruce budworm adults to monitor populations in this area. The objective of the project was to develop an effective system for monitoring budworm populations throughout this area during periods of low population density (endemic and early outbreak phase) and to establish at what point more intensive conventional sampling methods are required.

Method

In 1994 pheromone trap plots were selected at 41 locations to the east of Lake Winnipeg from the Winnipeg River north to Seymourville. In 1995 12 plot locations were eliminated as they had been included in the 1995 spruce budworm insecticide application program. Each year trap placement was carried out in the third to fourth week of June prior to adult moth emergence. All plots were placed at least 40 to 50 metres (m) from the stand boundary. Three Multi-Pher® insect traps containing spruce budworm pheromone (PVC lure containing 0.3% by weight of a 95:5 blend of (E)- and (Z)-11-tetradecenal) were placed 40 m apart at each plot location in either a straight or triangular configuration. A Hercon Vaportape® II insecticide strip was placed in the bottom of each trap in order to asphyxiate and capture moths which visited the trap. Each trap was hung on a branch two m above ground no less than 0.5 m from live spruce or fir foliage. Traps remained in the field for approximately six weeks. Traps were retrieved in the last week of July and first week of August. At each plot six 45 cm branches were collected from white spruce or balsam fir to assess defoliation and egg mass densities. Moth and egg mass counts and defoliation assessments were performed in the laboratory. Moth captures were compared to egg mass densities and defoliation in both the current and following year. Regression analysis was performed on the data to determine the strength of these relationships. Moth captures were also compared to subsequent defoliation using the moth per trap/risk of severe defoliation relationship (Ono 1994) as follows:

Average moths/trap	Risk of severe defoliation
< 500	Low
500-2000	Moderate
2000+	High

A similar comparison was made between egg mass densities and subsequent defoliation to determine the risk of severe defoliation when the prediction was light or moderate. The two methods of defoliation prediction could not be compared at the severe level as none of the plots averaged 2,000 or more moths.

Results

Moth captures ranged from 60 to 2,050 per trap over the three year period (Tables 1-3). The mean moth capture per trap ranged from a low of 97 to 1,921 (Tables 1-3). The mean moth capture per trap for all plots combined was 792 in 1994, 591 in 1995 and 629 in 1996. Moth captures per plot ranged from 291 to 5,762.

Regression analysis indicated a weak correlation between moth captures and subsequent egg mass densities. The correlation coefficients (r^2) were 0.37, 0.13 and 0.49 for 1994, 1995 and 1996 respectively.

The correlation between moth captures and the following year's defoliation was $r^2 = 0.29$ for 1994 moths and 1995 defoliation and $r^2 = 0.50$ for 1995 moths and 1996 defoliation.

The correlation between the current year's defoliation and moth captures was $r^2 = 0.20$ in 1994, $r^2 = 0.31$ in 1995 and $r^2 = 0.65$ in 1996.

When the data was analyzed using the moth capture per trap/risk of severe defoliation relationship, the moth capture values predicted defoliation more accurately than the regression analysis suggested it might. In the plots where the moth capture predicted the risk of severe defoliation to be low, 65% experienced light defoliation, 22% moderate defoliation and 13% severe defoliation the following year. In the plots where the moth capture predicted the risk of severe defoliation to be moderate, 19% experienced light defoliation, 61% moderate defoliation and 19% severe defoliation (Tables 4 and 5).

The comparison of egg mass densities to subsequent defoliation yielded similar results to that of the moth capture and subsequent defoliation. In the plots where light defoliation was predicted, 57% experienced light defoliation, 40% moderate defoliation and 3% severe defoliation. In the plots where moderate defoliation was predicted, 27% experienced light defoliation, 53% moderate defoliation and 20% severe defoliation (Tables 6 and 7).

Statistical analysis (contingency table) indicated that the two defoliation prediction methods (moth capture and egg mass densities) were not significantly different in their ability to predict the following year's defoliation at $p \leq 0.05$.

Discussion

Moth captures and egg mass densities produced similar results when used to predict subsequent defoliation. Statistical analysis showed the two methods were not significantly different. These results indicate that pheromone traps have the potential to be used as a predictive tool for spruce budworm defoliation. Pheromone trapping is less labour intensive than egg mass surveys and may be a useful alternative in certain situations. Therefore, it is recommended that the spruce budworm pheromone trap research project be continued to determine if this method can be used as an operational survey technique in Manitoba.

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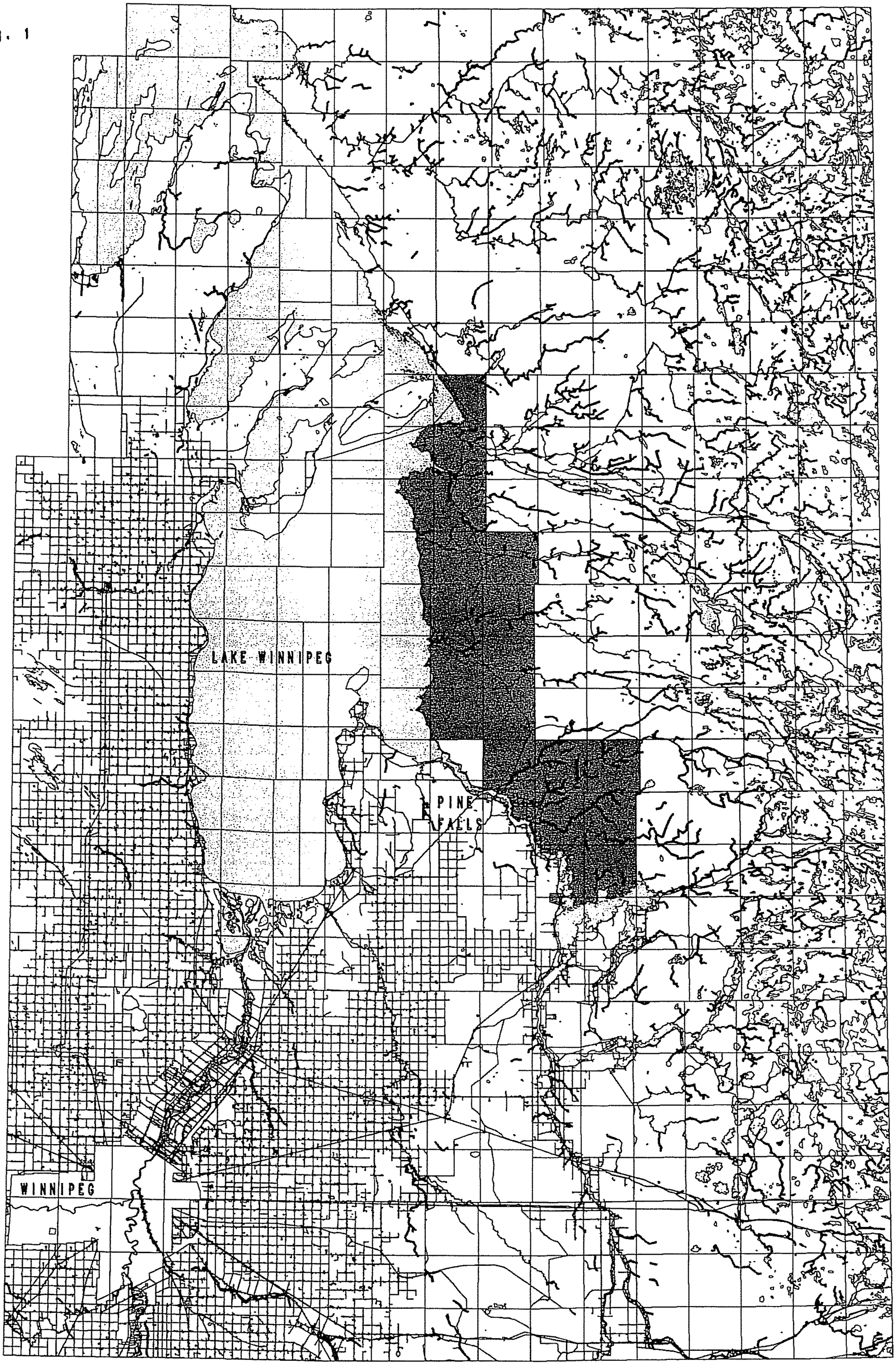
Fig. 1



MANITOBA MODEL FOREST
SPRUCE BUDWORM PHEROMONE TRAP PLACEMENT AREA
YEARS 1994-96
SCALE: 1: 1000000

MANITOBA NATURAL RESOURCES
FORESTRY BRANCH
FOREST HEALTH AND ECOLOGY SECTION

Table 1: Spruce Budworm Model Forest Pheromone Plots (1994)

Block	Plot	1994[1] Defoliation	1994 Moth Capture	1994 Egg Masses per 10 m^2 of Foliage
1	1	Severe	4,098 (1,366)	221
1	2	Light	3,083 (1,028)	44
1	3	Severe	5,540 (1,874)	60
1	4	Light	4,564 (1,521)	106
1	5	Moderate	3,541 (1,770)[2]	55
1	6	Moderate	4,974 (1,658)	100
1	7	Severe	1,231 (616)[2]	16
1	8	Moderate	5,762 (1,921)	111
1	9	Severe	2,136 (1,068)[2]	146
1	10	Light	1,304 (652)[2]	88
1	11	Light	825 (413)[2]	46
1	12	Light	1,911 (613)	12
1	13	Moderate	4,368 (1,456)	337
1	14	Light	2,619 (873)	242
1	15	Severe	2,606 (869)	171
5	1	Light	907 (302)	5
5	2	Light	597 (299)[1]	0
8	1	Light	411 (137)	7
8	2	Light	509 (170)	4
8	3	Light	439 (146)	0
8	4	Light	327 (109)	0
8	5	Severe	2,267 (756)	632
8	6	Light	2,652 (884)	6
8	7	Light	2,056 (685)	38
8	8	Severe	2,469 (832)	341
9	1	Light	880 (293)	48
9	2	Moderate	553 (227)[2]	5

1. Defoliation caused by larvae from eggs laid in 1993.
2. Data from only two traps.
Average moth capture per trap in parenthesis.

Table 1: Contd: Spruce Budworm Model Forest Pheromone Plots (1994)

Block	Plot	1994[1] Defoliation	1994 Moth Capture	1994 Egg Masses per 10 m^2 of Foliage
9	3	Light	486 (243)[2]	0
9	4	Moderate	3,763 (1,254)	33
9	6	Light	1,186 (593)[2]	32
9	7	Moderate	1,541 (514)	252
9	8	Severe	1,173 (391)	95
9	9	Moderate	2,039 (1,020)	410
9	10	Light	1,264 (632)	11
9	11	Extreme	1,085 (362)	360
9	12	Moderate	1,708 (569)	78
9	13	Extreme	3,358 (1,119)	171
9	14	Moderate	1,167 (389)	115
9	15	Moderate	2,268 (756)	230
9	16	Moderate	3,840 (1,280)	159

1. Defoliation caused by larvae from eggs laid in 1993.
2. Data from only two traps.
Average moth capture per trap in parenthesis.

Table 2: Spruce Budworm Model Forest Pheromone Plots (1995)

Block	Plot	1995[1] Defoliation	1995 Moth Capture	1995 Egg Masses per 10 m^2 of Foliage
1	1	Severe	3,190 (1,063)	52
1	4	Moderate	2,409 (803)	24
1	5	Moderate	3,603 (1,201)	18
1	10	Light	2,564 (855)	13
1	11	Light	505 (168)	29
1	12	Moderate	702 (243)	14
1	13	Moderate	2,812 (937)	29
1	14	Severe	3,154 (1,051)	373
1	15	Light	1,852 (617)	7
8	1	Light	293 (147)[2]	0
8	3	Light	752 (251)	10
8	4	Light	180 (180)[3]	0
9	1	Light	752 (251)	13
9	2	Light	291 (97)	0
9	3	Moderate	419 (140)	14
9	4	Moderate	2,017 (672)	47
9	6	Moderate	953 (318)	0
9	7	Moderate	1,860 (620)	16
9	8	Severe	1,860 (620)	141
9	9	Severe	4,690 (1,536)	0
9	10	Moderate	280 (140)[2]	0
9	11	Severe	390 (390)[3]	0
9	12	Moderate	1,270 (423)	24
9	13	Severe	2,580 (860)	0
9	14	Severe	1,460 (487)	0
9	15	Moderate	3,760 (1,253)	0
9	16	Moderate	1,270 (635)[2]	132

1. Defoliation caused by larvae from eggs laid in 1994
2. Data from only two traps.
3. Data from only one trap.
Average moth capture per trap in parenthesis.

Table 3: Spruce Budworm Model Forest Pheromone Plots (1996)

Block	Plot	1996[1] Defoliation	1996 Moth Capture	1996 Egg Masses per 10 m^2 of Foliage
1	1	Moderate	3,421 (1,140)	512
1	4	Moderate	2,467 (822)	460
1	5	Moderate	2,566 (1,283)	352
1	10	Moderate	1,589 (795)[1]	79
1	11	Light	1,291 (430)	84
1	12	Light	1,341 (447)	62
1	13	Severe	3,204 (1,068)	356
1	14	Severe	3,422 (1,141)	1,099
1	15	Moderate	2,361 (787)	220
8	1	Light	1,823 (608)	28
8	2	Light	819 (273)	6
8	3	Light	528 (264)[2]	0
8	4	Light	821 (274)	6
9	1	Moderate	1,213 (738)	171
9	2	Light	464 (155)	20
9	3	Light	439 (146)	0
9	4	Moderate	2,175 (725)	153
9	5	Light	1,187 (396)	5
9	6	Moderate	1,882 (627)	183
9	7	Moderate	2,353 (784)	51
9	8	Light	650 (217)	18
9	9	Light	1,890 (630)	0
9	10	Light	815 (272)	0
9	11	Light	1,173 (391)	455
9	12	Moderate	1,912 (637)	47
9	13	Light	2,050 (683)	31
9	14	Moderate	2,204 (735)	87
9	15	Light	2,278 (759)	0
9	16	Moderate	2,450 (817)	224

1. Defoliation caused by larvae from eggs laid in 1995.
2. Data from only two traps.
Average moth capture per trap in parenthesis.

Table 4: Moth Capture and Subsequent Defoliation

Block	Plot	1994 Moth Capture	1995[1] Defoliation	1995 Moth Capture	1996[2] Defoliation
1	1	4,098 (1,366)	Severe	3,190 (1,063)	Moderate
1	4	4,564 (1,521)	Moderate	2,409 (803)	Moderate
1	5	3,541 (1,770)[1]	Moderate	3,603 (1,201)	Moderate
1	10	1,304 (652)[1]	Light	2,564 (855)	Moderate
1	11	825 (413)[1]	Light	505 (168)	Light
1	12	1,911 (613)	Moderate	702 (243)	Light
1	13	4,368 (1,456)	Moderate	2,812 (937)	Severe
1	14	2,619 (873)	Severe	3,154 (1,051)	Severe
1	15	2,606 (869)	Light	1,852 (617)	Moderate
8	1	411 (137)	Light	293 (147)[1]	Light
8	3	439 (146)	Light	752 (251)	Light
8	4	327 (109)	Light	180 (180)[2]	Light
9	1	880 (293)	Light	752 (251)	Moderate
9	2	553 (227)[1]	Light	291 (97)	Light
9	3	486 (243)[1]	Moderate	419 (140)	Light
9	4	3,763 (1,254)	Moderate	2,017 (672)	Moderate
9	6	1,186 (593)[1]	Moderate	953 (318)	Light
9	7	1,541 (514)	Moderate	1,860 (620)	Moderate
9	8	1,173 (391)	Severe	1,860 (620)	Moderate
9	9	2,039 (1,020)	Severe	4,690 (1,536)	Light
9	10	1,264 (632)	Moderate	280 (140)[1]	Light
9	11	1,085 (362)	Severe	390 (390)[2]	Light
9	12	1,708 (569)	Moderate	1,270 (423)	Moderate
9	13	3,358 (1,119)	Severe	2,580 (860)	Light
9	14	1,167 (389)	Severe	1,460 (487)	Moderate
9	15	2,268 (756)	Moderate	3,760 (1,253)	Light
9	16	3,840 (1,280)	Moderate	1,270 (635)[1]	Moderate

1. Defoliation caused by larvae from eggs laid in 1994.
2. Defoliation caused by larvae from eggs laid in 1995.

Table 5: Risk of Severe Defoliation Based on Moth Captures and Subsequent Observed Defoliation

Risk of Severe Defoliation	Observed Defoliation	Percent Occurrence
Low (<500 Moth/Trap)	Light	65%
Low (<500 Moth/Trap)	Moderate	22%
Low (<500 Moth/Trap)	Severe	13%
Moderate (500-2000 Moth/Trap)	Light	19%
Moderate (500-2000 Moth/Trap)	Moderate	61%
Moderate (500-2000 Moth/Trap)	Severe	19%

Table 6: Egg Mass Densities and Subsequent Defoliation

Block	Plot	1994 Egg Mass/10m^2 of Foliage	1995[1] Defoliation	1995 Egg Mass/10m^2 of Foliage	1996[2] Defoliation
1	1	221	Severe	52	Moderate
1	4	106	Moderate	24	Moderate
1	5	55	Moderate	18	Moderate
1	10	88	Light	13	Moderate
1	11	46	Light	29	Light
1	12	12	Moderate	14	Light
1	13	337	Moderate	29	Severe
1	14	242	Severe	373	Severe
1	15	171	Light	7	Moderate
8	1	7	Light	0	Light
8	3	0	Light	10	Light
8	4	0	Light	0	Light
9	1	48	Light	13	Moderate
9	2	5	Light	0	Light
9	3	0	Moderate	14	Light
9	4	337	Moderate	47	Moderate
9	6	32	Moderate	0	Light
9	7	252	Moderate	16	Moderate
9	8	95	Severe	141	Moderate
9	9	410	Severe	0	Light
9	10	11	Moderate	0	Light
9	11	360	Severe	0	Light
9	12	78	Moderate	24	Moderate
9	13	171	Severe	0	Light
9	14	115	Severe	0	Moderate
9	15	230	Moderate	0	Light
9	16	159	Moderate	132	Moderate

1. Defoliation caused by larvae from eggs laid in 1994.
2. Defoliation caused by larvae from eggs laid in 1995.

Table 7: Defoliation Prediction Based on Egg Mass Densities and Subsequent Observed Defoliation

Defoliation Prediction	Observed Defoliation	Percent Occurrence
Light (<40 Egg mass/10m^2 Foliage)	Light	57%
Light (<40 Egg mass/10m^2 Foliage)	Moderate	40%
Light (<40 Egg mass/10m^2 Foliage)	Severe	3%
Moderate (40-185 Egg mass/10m^2 Foliage)	Light	27%
Moderate (40-185 Egg mass/10m^2 Foliage)	Moderate	53%
Moderate (40-185 Egg mass/10m^2 Foliage)	Severe	20%
Severe (>185 Egg mass/10m^2 Foliage)	Light	0%
Severe (>185 Egg mass/10m^2 Foliage)	Moderate	44%
Severe (>185 Egg mass/10m^2 Foliage)	Severe	56%