

**Impact of chilling Degree-Days on mortality of SWD using data from: Dalton D., V. Walton, et. al. 2012. Laboratory survival of *Drosophila suzukii* under simulated winter conditions of the Pacific Northwest and seasonal field trapping in five primary regions of small and stone fruit production in the United States**

Field data from: Dreves et al. 2009-2011; Shearer and Castagnoli 2010-2011

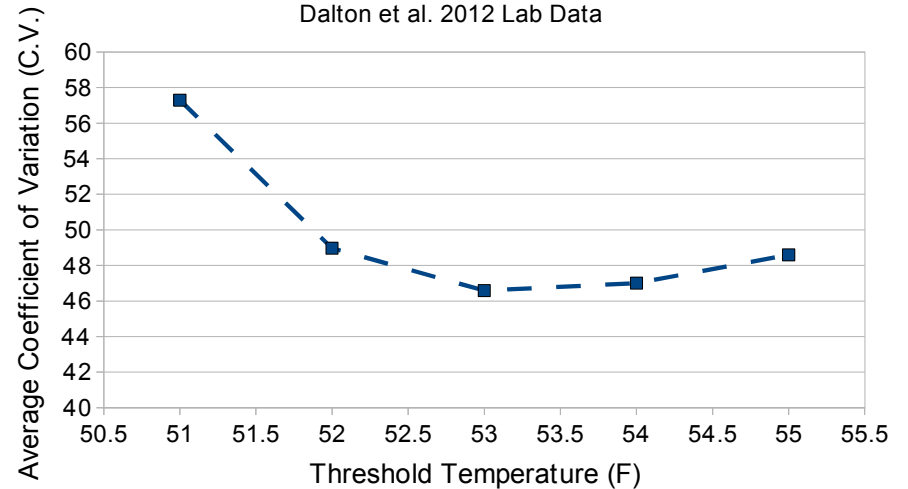
Modeling analysis by Len Coop – revised Dec. 2011

**1. Model Development I. Determine chilling unit threshold using lowest C.V. Method (lowest error rate), Dalton et al. 2012, Fig. 1 – Adult survival no freeze and Table 1, also Adults no freeze**

Best fit values w/Salmon colored cell background

		(candidate temperatures to use as threshold:)																																																											
Threshold temps:		51				52				53				54																																															
Temp degC	deg F	Days to 20% mortality				Upper Threshold (F) for Chill DDs:				Days to 40% mortality				Upper Threshold (F) for Chill DDs:				Days to 50% mortality				Upper Threshold (F) for Chill DDs:																																							
		Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:																																											
10	50	18	18	36	54	72	37	37	74	111	148	53	53	106	159	212																																													
7	44.6	7.5	48	55.5	63	70.5	14	89.6	103.6	117.6	131.6	15	96	111	126	141																																													
5	41	7	70	77	84	91	13	130	143	156	169	13	130	143	156	169																																													
3	37.4	2.5	34	36.5	39	41.5	3.5	47.6	51.1	54.6	58.1	3.5	47.6	51.1	54.6	58.1																																													
1	33.8	2	34.4	36.4	38.4	40.4	3	51.6	54.6	57.6	60.6	2.5	43	45.5	48	50.5																																													
Lowest CV exclude 50F	mean	46.6				51.35				56.1				60.85				79.7				88.08				96.45				104.83				79.15				87.65				96.15				104.65															
	st dev	16.9				19.31				21.85				24.46				38.51				43.76				49.17				54.69				41.52				47.33				53.28				59.33															
	CV	36.27				37.61				38.94				40.2				48.31				49.69				50.98				52.18				52.46				54				55.42				56.7															
Lowest CV include 50F	mean	40.88				48.28				55.68				63.08				71.16				85.26				99.36				113.46				73.92				91.32				108.72				126.12															
	st dev	19.44				18.08				18.94				21.76				38.43				38.42				43.08				51.15				37.81				41.81				54.03				70.32															
	CV	47.55				37.45				34.02				34.5				54				45.06				43.36				45.08				51.15				45.78				49.7				55.76															
Temp degC	deg F	Days to 70% mortality				51				52				53				54				90% mortality				51				52				53				54				99% mortality				51				52				53				54			
		Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:				Chilling Dds:											
10	50	61	61	122	183	244	76	76	152	228	304	90	90	180	270	360																																													
7	44.6	27	172.8	199.8	226.8	253.8	38	243.2	281.2	319.2	357.2	80	512	592	672	752																																													
5	41	25	250	275	300	325	34	340	374	408	442	60	600	660	720	780																																													
3	37.4	5.5	74.8	80.3	85.8	91.3	17	231.2	248.2	265.2	282.2	80	1088	1168	1248	1328																																													
1	33.8	4	68.8	72.8	76.8	80.8	7	120.4	127.4	134.4	141.4	17	292.4	309.4	326.4	343.4																																													
Lowest CV exclude 50F	mean	141.6				156.98				172.35				187.73				233.7				257.7				281.7				305.7				623.1				682.35				741.6				800.85															
	st dev	86.58				97.86				109.36				121.02				89.88				101.89				114.5				127.51				335.84				357.59				380.41				404.13															
	CV	61.14				62.34				63.45				64.47				38.46				39.54				40.64				41.71				53.9				52.41				51.3				50.46															
Lowest CV include 50F	mean	125.48				149.98				174.48				198.98				202.16				236.56				270.96				305.36				516.48				581.88				647.28				712.68															
	st dev	83.19				86.18				94.83				107.79				105.03				100.11				102.02				110.43				376.07				382.59				391.17				401.7															
	CV	66.3				57.46				54.35				54.17				51.96				42.32				37.65				36.16				72.81				65.75				60.43				56.36															
Threshold tem		51				52				53				54				55																																											
avg CV		57.3				48.97				46.59				47.01				48.59																																											
Lowest C.V.: 53 F use this as threshold temperature for accumulating Chilling Dds		10.56				11.11				11.67				12.22				12.78																																											

**SWD Chilling Model - Threshold Determination**  
Dalton et al. 2012 Lab Data



1.1. Resulting Chilling DD model is: at 56 Dds below 53F, expect 20% mortal, at 99 Dds, expect 40% mortal, at 109 chill DDs, expect 50% mortal. At 271 chill deg-days, expect 90% mortal. At 647 chill deg-days, expect 99% mortal.

Chilling DDs	%mortal
56	20
99	40
109	50
174	70
271	90
647	99

2. Model Development II. Fit a function to the results so that for any given Chilling DD value, the associated % mortality can be estimated:

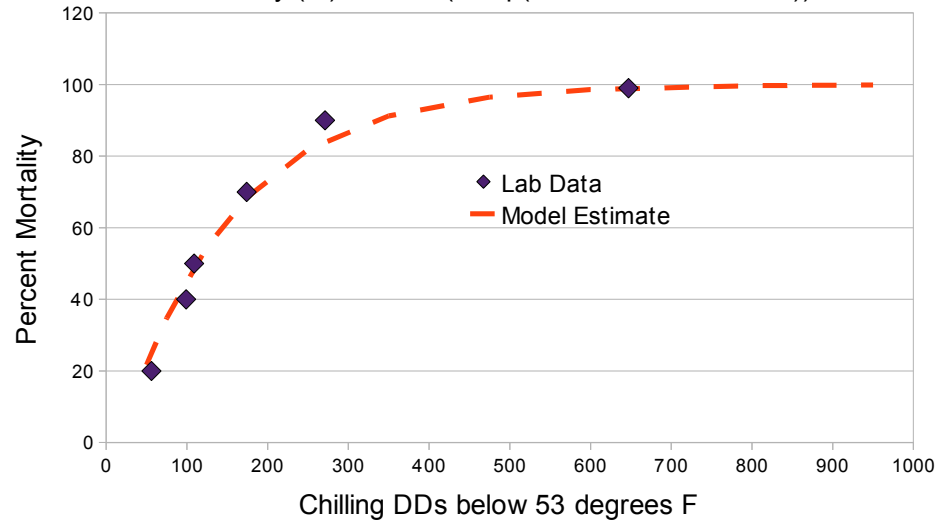
Assumptions: Fitting 99% mortality most important; a more conservative model is preferable (so mortality would be underestimated instead of overestimated)

Exponential Saturation Model fit empirically:  
 Model form: %mortal.=a\*(1-exp(b\*chill\_DDs+c))  
 Parameters:  
 a= 100.00  
 b= -0.00730  
 c= 0.12000

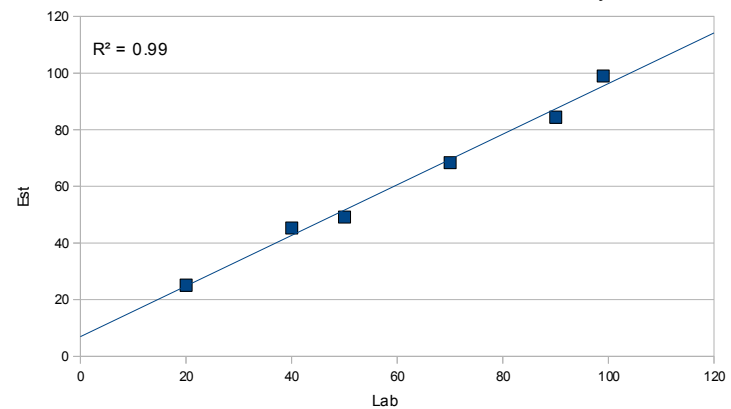
Chilling DDs	Model Estima	Lab Data	% mortality model
50	21.73		
75	34.79		
125	54.73		
175	68.57		
250	81.82		
350	91.24		
475	96.48		
600	98.59		
800	99.6720		
950	99.890281		
56		20	25.08
99		40	45.27
109		50	49.12
174		70	68.34
271		90	84.41
647		99	98.9979

R<sup>2</sup> = 0.99033  
 slope = 0.89415  
 intercept = 6.87904

Fitted Model - Overwintering Survival using Chilling DDs  
 Dalton et al. 2012 lab data (no freeze)  
 Mortality (%) = 100 x (1-exp(-0.0073 x DDs + 0.12))



Cross-check: Lab vs Model Estimated % Mortality



### 3. Model Evaluation I. Cross check chilling DD model vs. Dalton et al. 2012 lab data with freeze exposure at -2C for 7 days from day 18 to day 25 (Table 1, Fig. 2)

Thresh F	Treatment T DegC	Treatment T Deg F	Chill DDs below 53F	Chill DDs 7 days @28F												
53	-2	28.4	24.6	172.2												
Note: chill Dds due to freeze added if days to mortality exceeds 18																
Temp C	Temp F	-2 Days to 25% mortality	Chill DDs	Model % mortal	Days to 50% mortality	Chill DDs	Model % mortal	Days to 75% mortality	Chill DDs	Model % mortal	Days to 99% mortality	Chill DDs	Model % mortal	Days to 100% mortality	Chill DDs	Model % mortal
10	50	11	3	-10.31	29	238.2	80.19	66	349.2	91.19	80	391.2	93.52	84	403.2	94.06
7	44.6	8	67.2	30.97	14	117.6	52.22	29	357	91.68	84	819	99.71 na			
5	41	5	60	27.24	14	168	66.93	29	436.2	95.33	50	688.2	99.26	63	844.2	99.76
3	37.4	3	46.8	19.88	3	46.8	19.88	8	124.8	54.66	29	515.4	97.38	29	515.4	97.38
1	33.8	3	57.6	25.95	3	57.6	25.95	3	57.6	25.95	NA		NA			
	mean		46.92	18.75		125.64	49.03		264.96	71.76		603.45	97.47		679.8	97.07
	st dev		25.62			79.65			163.96			188.37			232.5	
	CV		54.6			63.39			61.88			31.22			34.2	

Temp C	Temp F	Days to 50% mortality	Chill DDs	Model % mortal	Days to 80% mortality	Chill DDs	Model % mortal	Days to 99% mortality	Chill DDs	Model % mortal	
10	50	29	238.2	80.19	70	361.2	92.84	83	400.2	94.61	
7	44.6	14	117.6	52.22	29	357	92.62	29	357	92.62	
5	41	15	180	69.7	29	436.2	95.86	47	652.2	99.14	
3	37.4	3	46.8	19.88	8	124.8	59.79	25	453	96.34	
1	33.8	2.8	53.76	23.85	6	115.2	56.87	na			
	mean		127.27	49.17		278.88	79.6		465.6	95.68	
	st dev		82.25			148.46			130.45		
	CV		64.62			53.23			28.02	mean CV	48.9

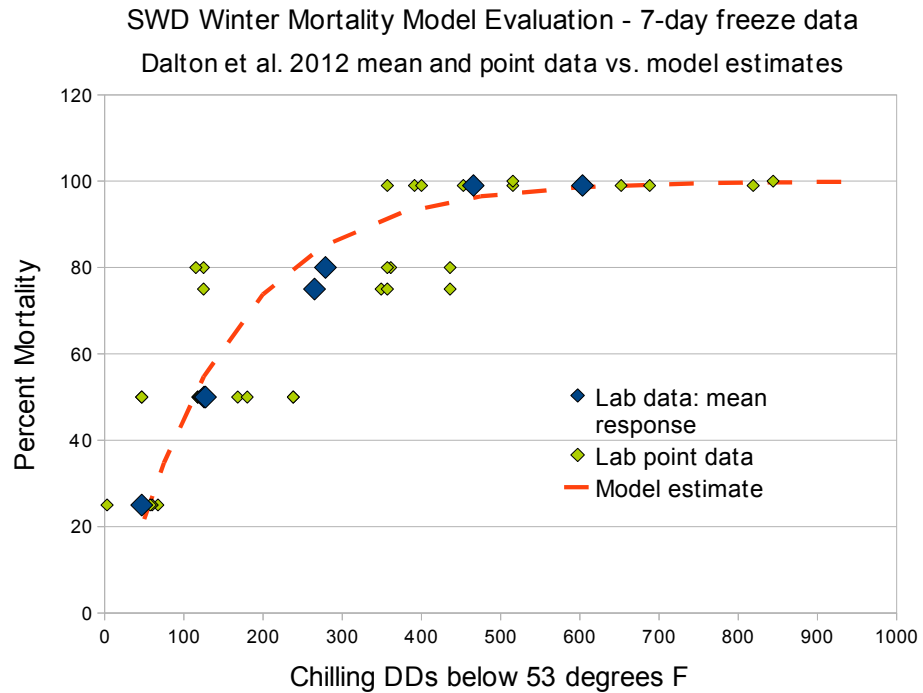
### 3.1 Cross check lowest CV determination of upper threshold to use for chilling Dds

Thresh F:	46	48	50	52	53	54	55	56	57
C.V.:	55.33	52.07	52.16	49.08	48.9	49.17	49.71	50.41	51.17

Conclusion: 53 F appears again to be the threshold with the lowest C.V.

### 3.2 Graph of model evaluation using 7-day freeze data of Dalton et al. 2012:

Chilling DDs	Lab data: mean	Model estimate	Lab point data
46.92	25		
125.64	50		
264.96	75		
603.45	99		
127.27	50		
278.88	80		
465.6	99		
50	21.73		
75	34.79		
125	54.73		
200	73.82		
275	84.86		
375	92.7		
475	96.48		
600	98.59		
750	99.53		
950	99.89		
3		25	
67.2		25	
60		25	
46.8		25	
57.6		25	
238.2		50	
117.6		50	
168		50	
46.8		50	
349.2		75	
357		75	
436.2		75	
124.8		75	
391.2		99	

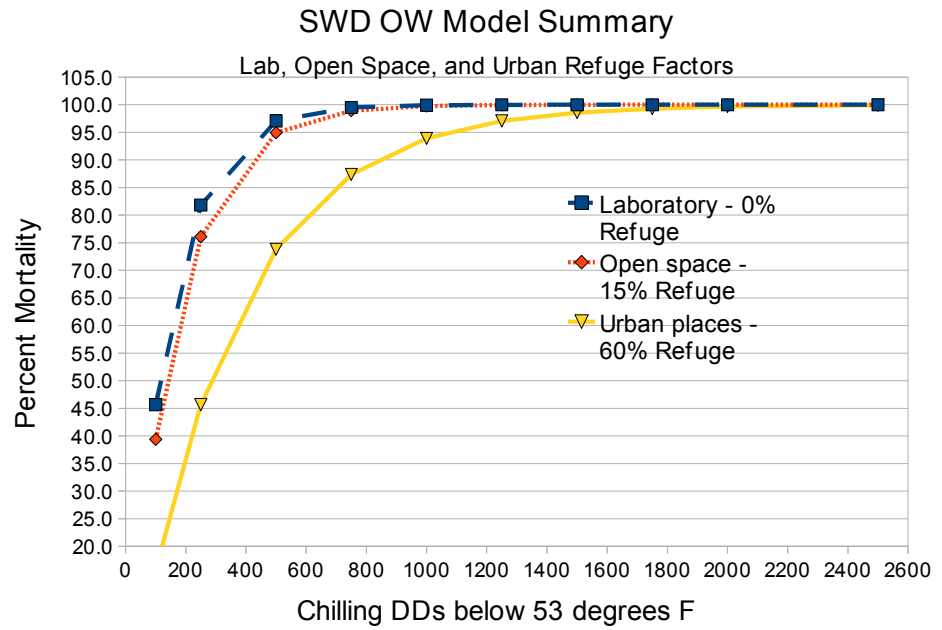


819	99
688.2	99
515.4	99
844.2	100
515.4	100
238.2	50
117.6	50
180	50
46.8	50
361.2	80
357	80
436.2	80
124.8	80
115.2	80
400.2	99
357	99
652.2	99
453	99

#### 4. Summary of model using Refuge Factors for a range of habitats

Rf Open space: 0.15  
Rf Urban places: 0.6

event	Chilling DDs	Laboratory - 0% Refuge	Open space - 15% Refuge	Urban places - 60% Refuge
1	100	45.66491		
2	250	81.82276		
3	500	97.06951		
4	750	99.52755		
5	1000	99.92383		
6	1250	99.98772		
7	1500	99.99802		
8	1750	99.99968		
9	2000	99.99995		
10	2500	100.00000		
	100	39.37725		
	250	76.09900		
	500	94.93340		
	750	98.92597		
	1000	99.77232		
	1250	99.95174	5 out of 1000 survive	
	1500	99.98977	1 out of 10,000 survive	
	1750	99.99783	2 out of 100,000 survive	
	2000	99.99954	5 out of 1 million survive	
	2500	99.99998	2 out of 10 million survive	
	100	15.80208		
	250	45.66491		
	500	73.81543		
	750	87.38142		
	1000	93.91899		
	1250	97.06951	3 out of 100 survive	
	1500	98.58777	5 out of 200 survive	
	1750	99.31943	7 out of 1000 survive	
	2000	99.67203	3 out of 1000 survive	
	2500	99.92383	8 out of 10,000 survive	

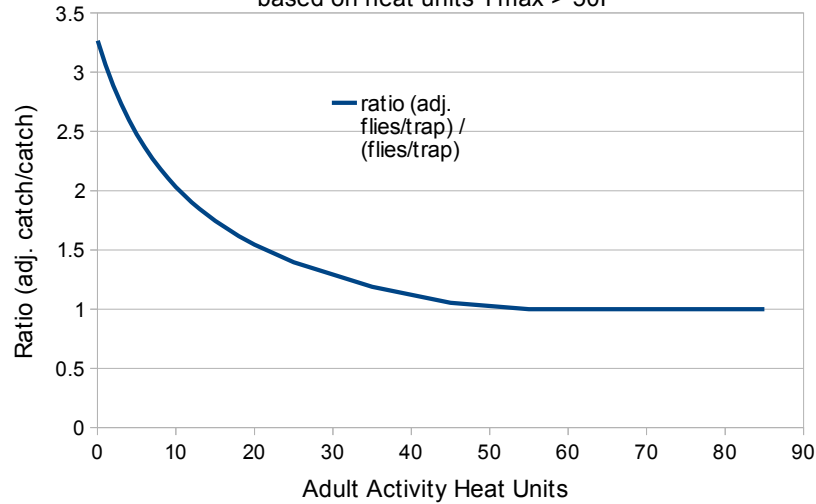


### 5. Model to standardize trap catch using Adult Activity Heat Units (AAHU):

This approach should help to visualize and interpret trap counts taken when weather is cool relative to SWD activity; This model is highly preliminary and subject to updates.

Activ. Heat	Unratio (adj. flies/Files/trap)	proportion				max AAHUs	log (P maxau)	adj trap #	adj using log	ratio
		AAHU = 2	AAHU = 15	AAHU = 30	AAHU = 45					
0.01	3.27	1	3.27			20.02	1.3	5	1.54	3.27
1	3.06	10	30.64			21.6	1.33	46.3	14.99	3.06
2	2.89	50	144.38			23.2	1.37	215.52	73.23	2.89
3	2.73	100	273.33			24.8	1.39	403.23	143.43	2.73
4	2.6	225	584.41			26.4	1.42	852.27	316.54	2.6
5	2.48	350	866.85			28	1.45	1250	483.71	2.48
6	2.37	1		2.37		29.6	1.47	3.38	1.36	2.37
7	2.27	10		22.72		31.2	1.49	32.05	13.39	2.27
8	2.18	50		109.2		32.8	1.52	152.44	65.97	2.18
9	2.1	100		210.43		34.4	1.54	290.7	130.16	2.1
10	2.03	225		457.07		36	1.56	625	289.15	2.03
11	1.96	350		687.62		37.6	1.58	930.85	444.39	1.96
12	1.9	1			1.9	39.2	1.59	2.55	1.26	1.9
13	1.85	10			18.46	40.8	1.61	24.51	12.42	1.85
15	1.74	50			87.24	44	1.64	113.64	60.85	1.74
18	1.62	100			161.69	48.8	1.69	204.92	118.45	1.62
20	1.54	225			347.46	52	1.72	432.69	262.24	1.54
25	1.4	350			488.5	60	1.78	583.33	393.67	1.4
35	1.19	1				76	1.88	1.32	1.06	1.19
45	1.05	10				10.53	1.96	10.87	10.18	1.05
55	1	50				50	2	50	50	1
65	1	100				100	2	100	100	1
75	1	225				225	2	225	225	1
85	1	350				350	2	350	350	1

Model to Adjust SWD Trap Catch based on heat units Tmax > 50F



Adjustment of SWD Overwintering Trap Data for Temperature Using Adult Activity Heat Units (AAHU)

