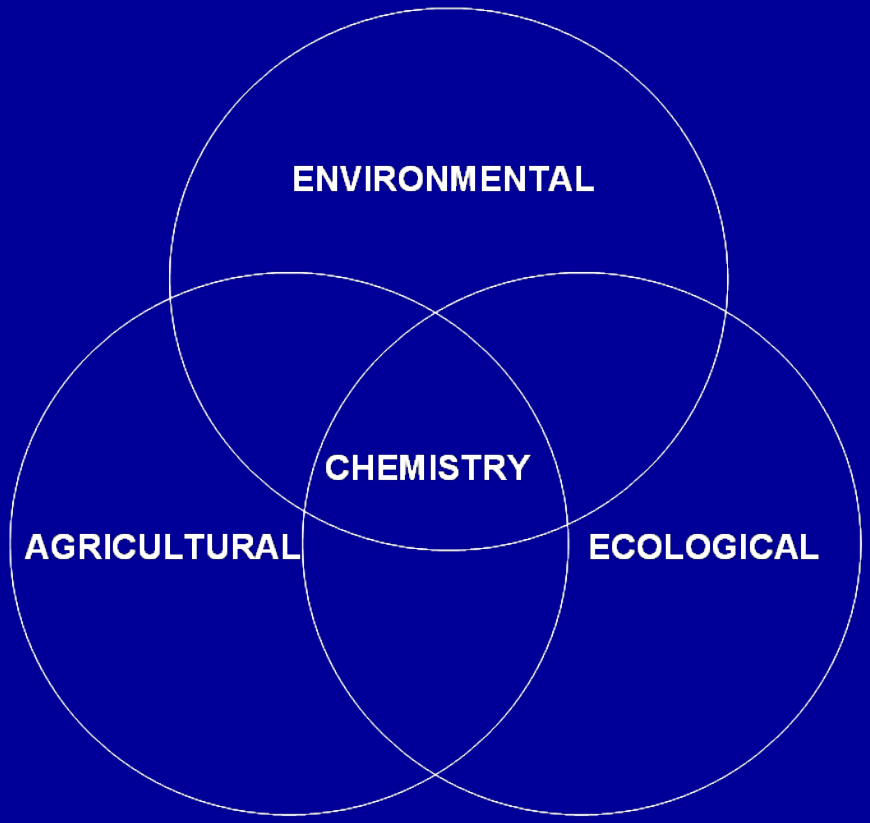
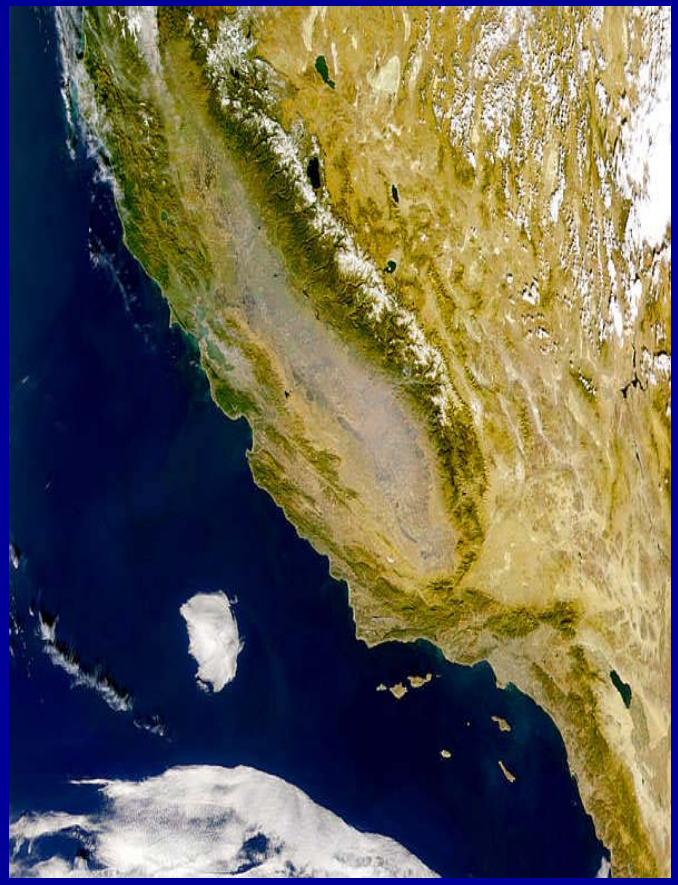
Fumigation and Natural Products

Spencer S. Walse





Chamber fumigation: facilities

9ft3

Insectary, 17 species
Steve Tebbets

155ft3

1ft3

30ft3

Schedule development for chamber fumigations: quarantine scenarios

LBAM

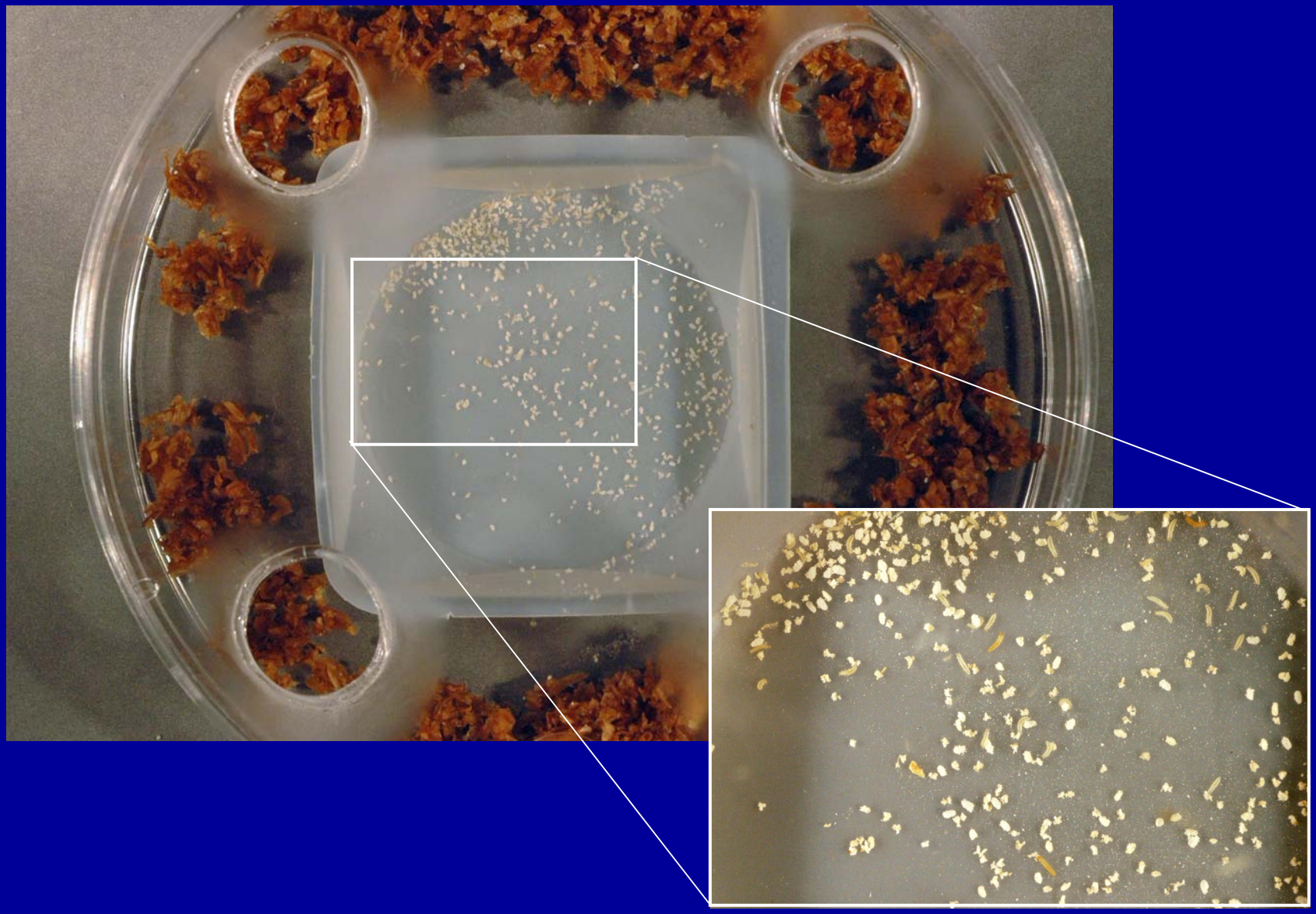
PTB

CVF

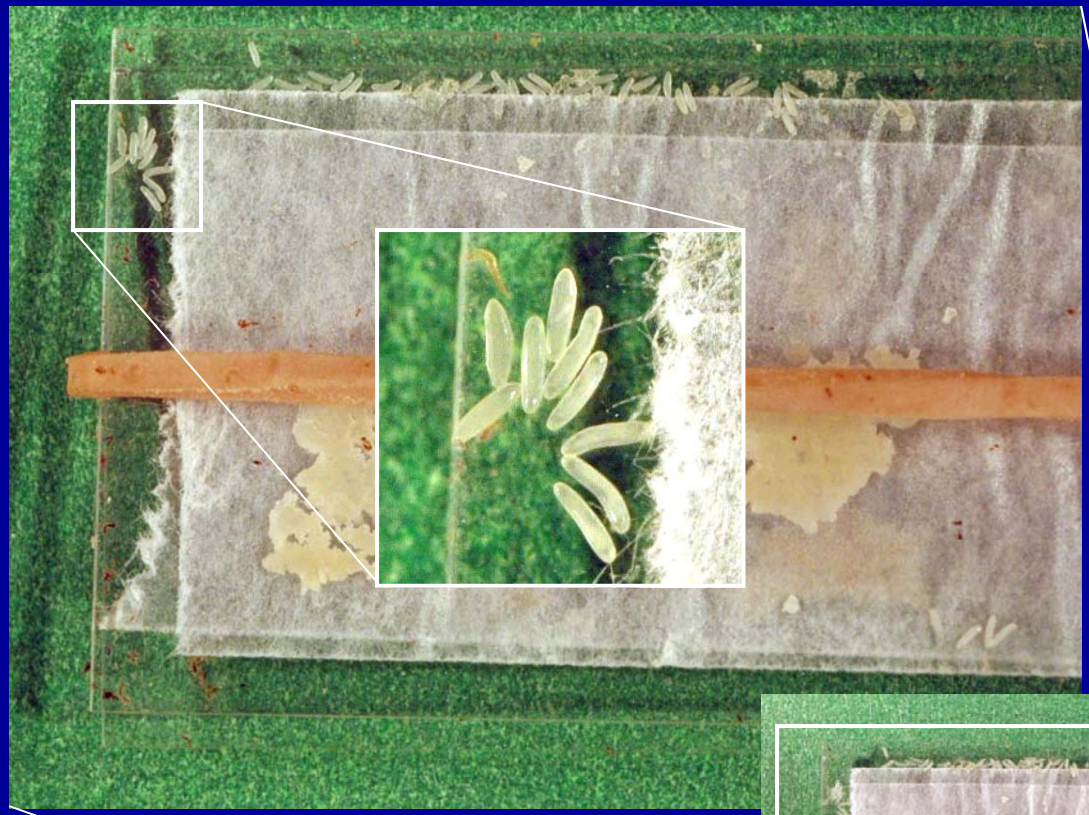
Sulfuryl fluoride for insect pests of dried fruit & nuts

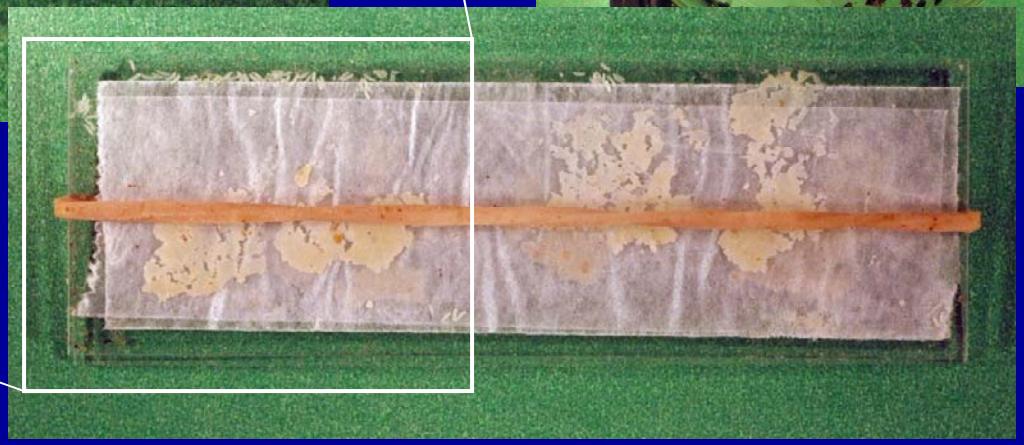
MeBr Schedule	Test Insect (Spp)*		80F			70F			60F		
			LD	LL	UL	LD	LL	UL	LD	LL	UL
24 hr NAP	IMM	LD50	5.4	4.6	6.1	10.9	10.1	11.7	18.9	15.2	21.8
		LD95	14.6	12.1	19.1	25.5	22.5	30.0	41.9	33.9	66.3
		LDP9	60.9	39.9	117.7	86.5	65.7	125.3	131.1	77.8	449.7
		Slope (+/-)	3.80	0.16		4.44	0.19		4.76	0.22	
		Heterogeneity	7.05			2.92			18.29		
	RFB	LD50	27.1	23.1	30.0	33.0	28.5	36.7	36.3	31.1	40.9
		LD95	43.6	38.8	54.0	78.8	68.7	96.7	87.4	76.0	106.6
		LDP9	86.3	65.4	155.5	274.8	192.4	486.3	307.6	217.4	529.7
		Slope (+/-)	7.96	0.61		4.34	0.25		4.31	0.18	
		Heterogeneity	4.97			3.94			6.84		
	DFB	LD50	56.5	51.8	60.4	75.5	54.6	95.4	220.6	184.9	246.8
		LD95	88.2	79.9	104.1	273.9	181.3	793.2	453.4	389.6	596.4
		LDP9	167.2	132.6	254.5	1737.2	655.1	25371.0	1274.5	861.7	2773.1
		Slope (+/-)	8.49	0.40		2.70	0.19		5.29	0.23	
		Heterogeneity	8.43			4.97			12.35		

Method Used for Exposure of IMM or RFB Eggs to Sulfuryl Fluoride Fumigation Trials

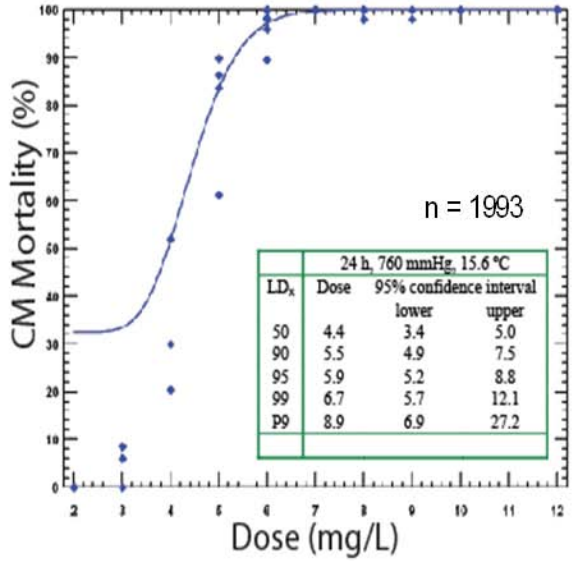


Method Used for Egg Collection and Exposure of DFB Eggs to Sulfuryl Fluoride Fumigation Trials

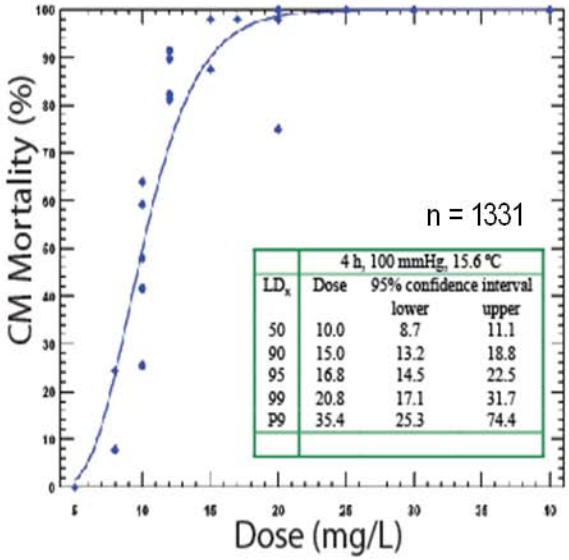




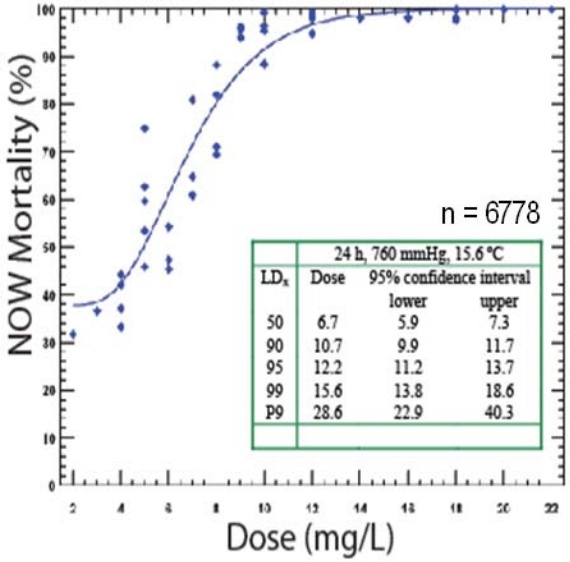
Sulfuryl fluoride for insect pests of walnuts



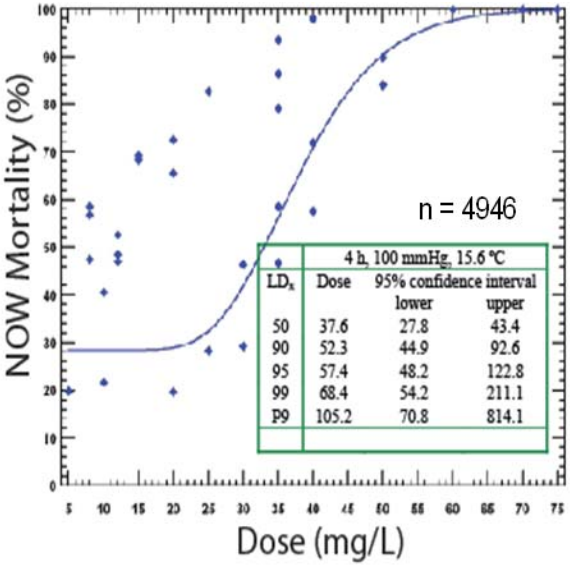
	24 h, 760 mmHg, 15.6 °C		
LD_x	Dose	95% confidence interval lower	upper
50	4.4	3.4	5.0
90	5.5	4.9	7.5
95	5.9	5.2	8.8
99	6.7	5.7	12.1
P9	8.9	6.9	27.2



	4 h, 100 mmHg, 15.6 °C		
LD_x	Dose	95% confidence interval lower	upper
50	10.0	8.7	11.1
90	15.0	13.2	18.8
95	16.8	14.5	22.5
99	20.8	17.1	31.7
P9	35.4	25.3	74.4



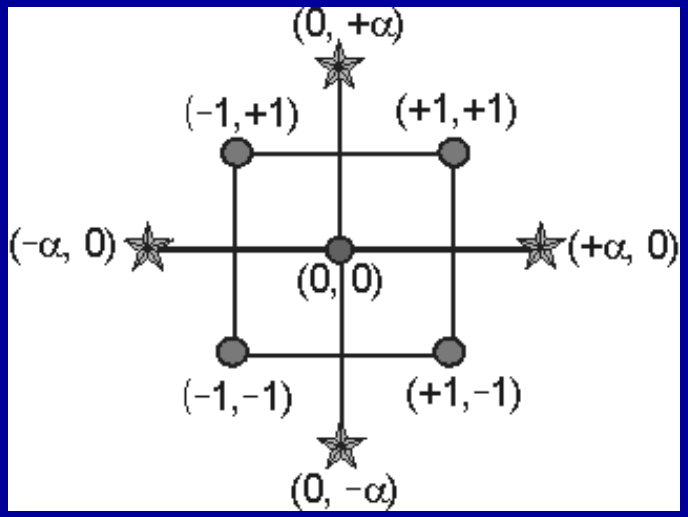
	24 h, 760 mmHg, 15.6 °C		
LD_x	Dose	95% confidence interval lower	upper
50	6.7	5.9	7.3
90	10.7	9.9	11.7
95	12.2	11.2	13.7
99	15.6	13.8	18.6
P9	28.6	22.9	40.3



	4 h, 100 mmHg, 15.6 °C		
LD_x	Dose	95% confidence interval lower	upper
50	37.6	27.8	43.4
90	52.3	44.9	92.6
95	57.4	48.2	122.8
99	68.4	54.2	211.1
P9	105.2	70.8	814.1

Mathematical modeling of fumigant effectiveness

Factor (original units)	*Factor levels*				
	-α	-1	0[a]	1	α
x_1: dose (mg/L)	0	24	48	72	96
x_2: temp (°C)	5	10	15	20	25
x_3: duration (h)	1	12	24	36	48
x_4: pressure (- inch. Hg)	0	7	14	21	28



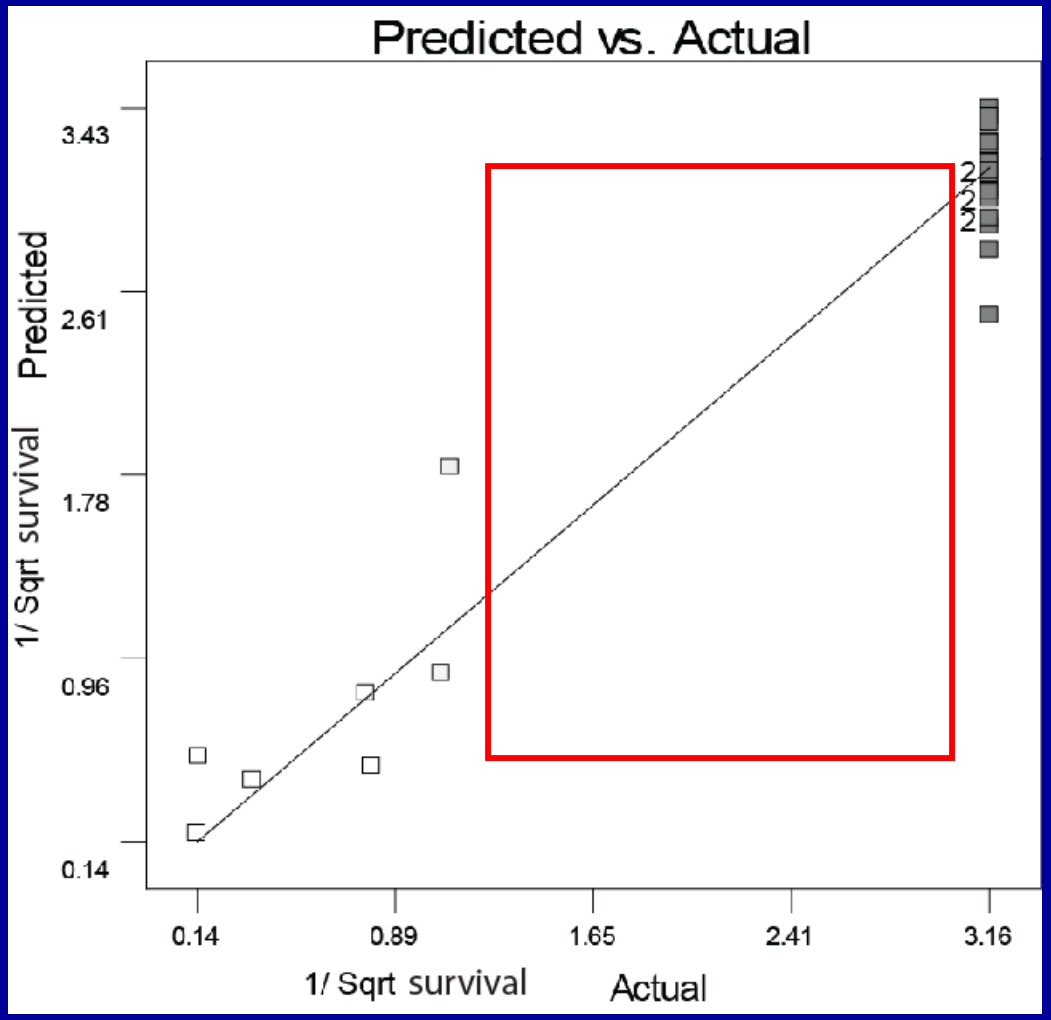
central-composite design
(matrix comparison)

$$y = \beta_0 + \beta_1 x_1 + \beta_{11} x_1^2 + \beta_2 x_2 + \beta_{22} x_2^2 + \beta_3 x_3 + \beta_{33} x_3^2 + \beta_4 x_4 + \beta_{44} x_4^2 + \beta_{12} x_1 x_2 + \beta_{13} x_1 x_3 + \beta_{14} x_1 x_4 + \beta_{23} x_2 x_3 + \beta_{24} x_2 x_4 + \beta_{34} x_3 x_4$$

Mathematical modeling of fumigant effectiveness: Quarantine scenarios!

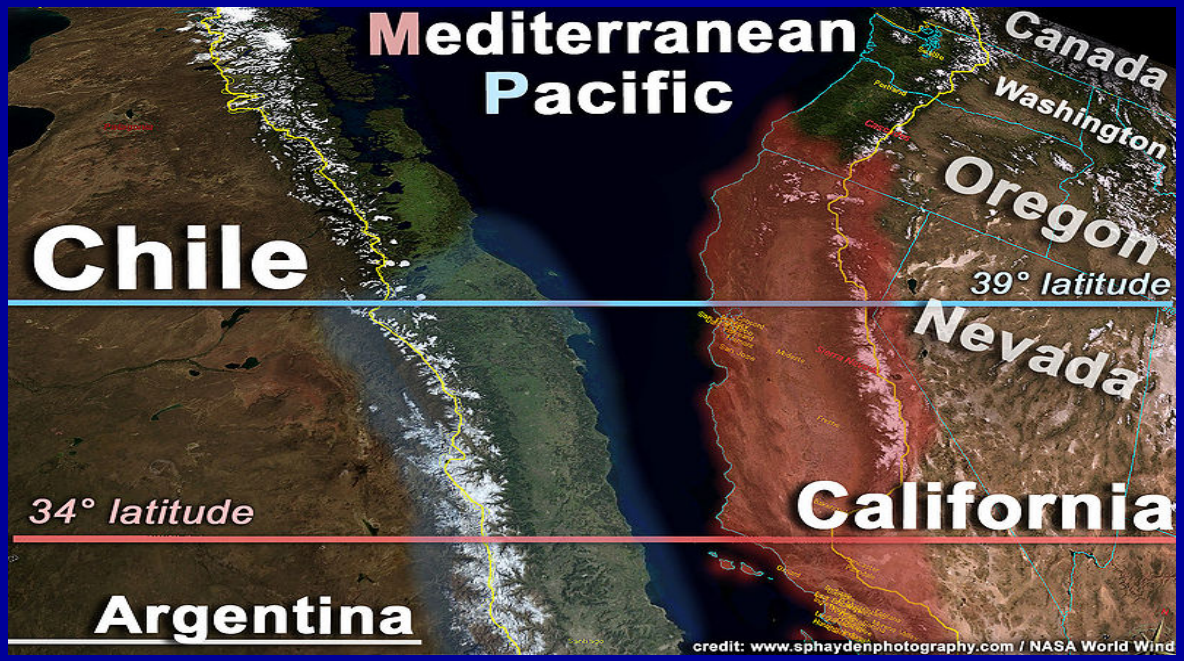
$$y^{-1/2} = 3.16 + 0.57x_1 + 0.74x_3 - 0.37x_1^2 - 0.37x_3^2 - 0.18x_1x_2 + 0.47x_1x_3$$

$r^2 = 0.89$



Application of the Horn method to CA pests and infrastructure: High PH3, Low Temp.

- Chilean protocol on reciprocals
  - “chilean” mites, leps, thrips, scales, mealys, true bugs
  - mitigation purposes (quarantine?)
- Citrus, Stone fruit
  - 24 to 48 hours at 1500 – 2000 ppm, ~5°C.

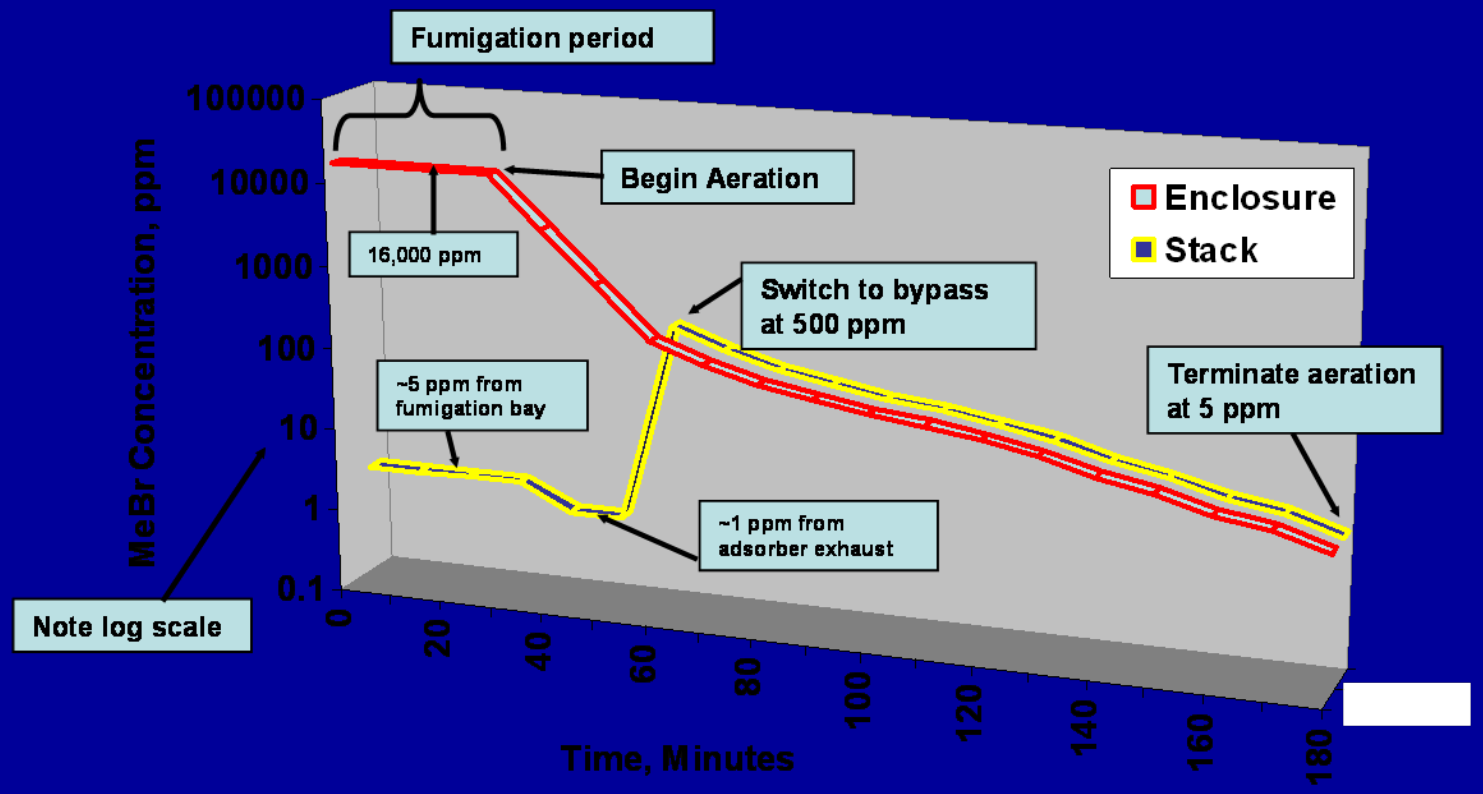


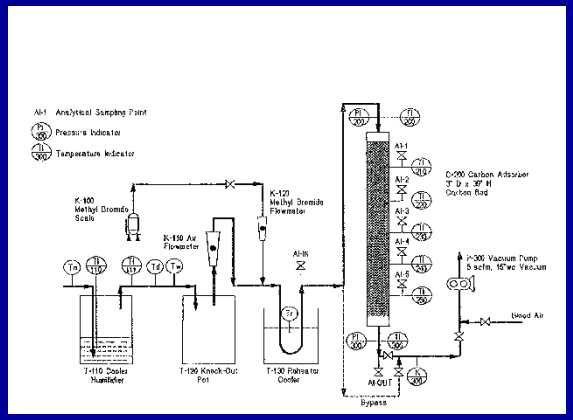
Why phosphine ?

- Being commercially employed by “competitors”
  - Scalability driven by Horn generator (collaborator)
- Generic mode of toxic action
- Works under cold-storage (~5°C)
- Cheap $3.2/lb (MB $ 6.75/lb)
- Limited residues (phosphate)
- Excellent penetrator

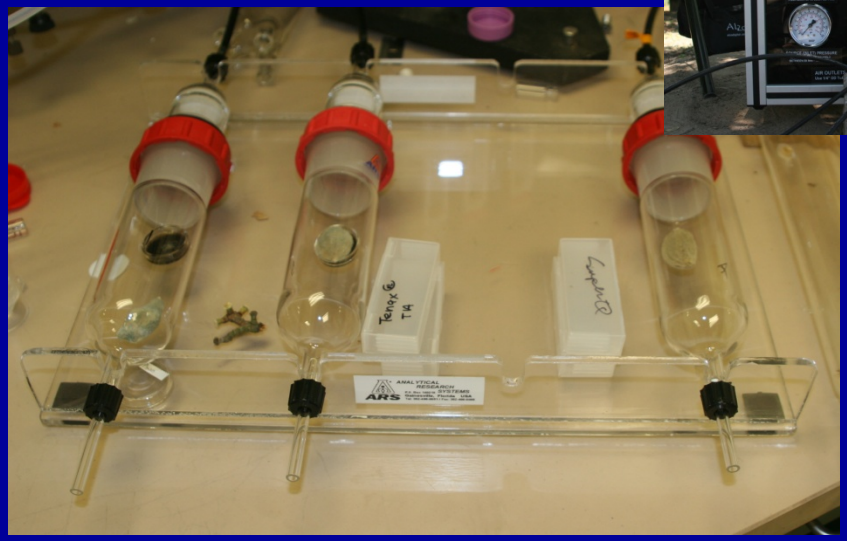
Phosphine scalability and throughput: Price-tag on the infrastructural change

Development of low-emission chamber fumigations





Degradation of economically important tree nuts



Design of pheromone release matrices: *natural inspiration*

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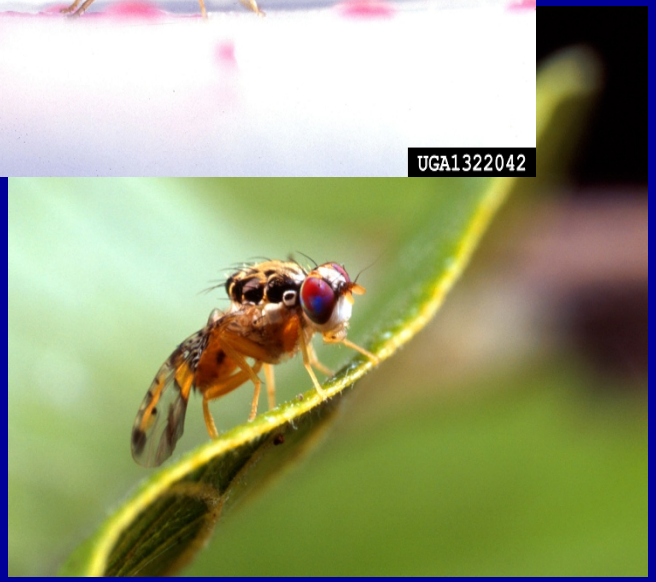
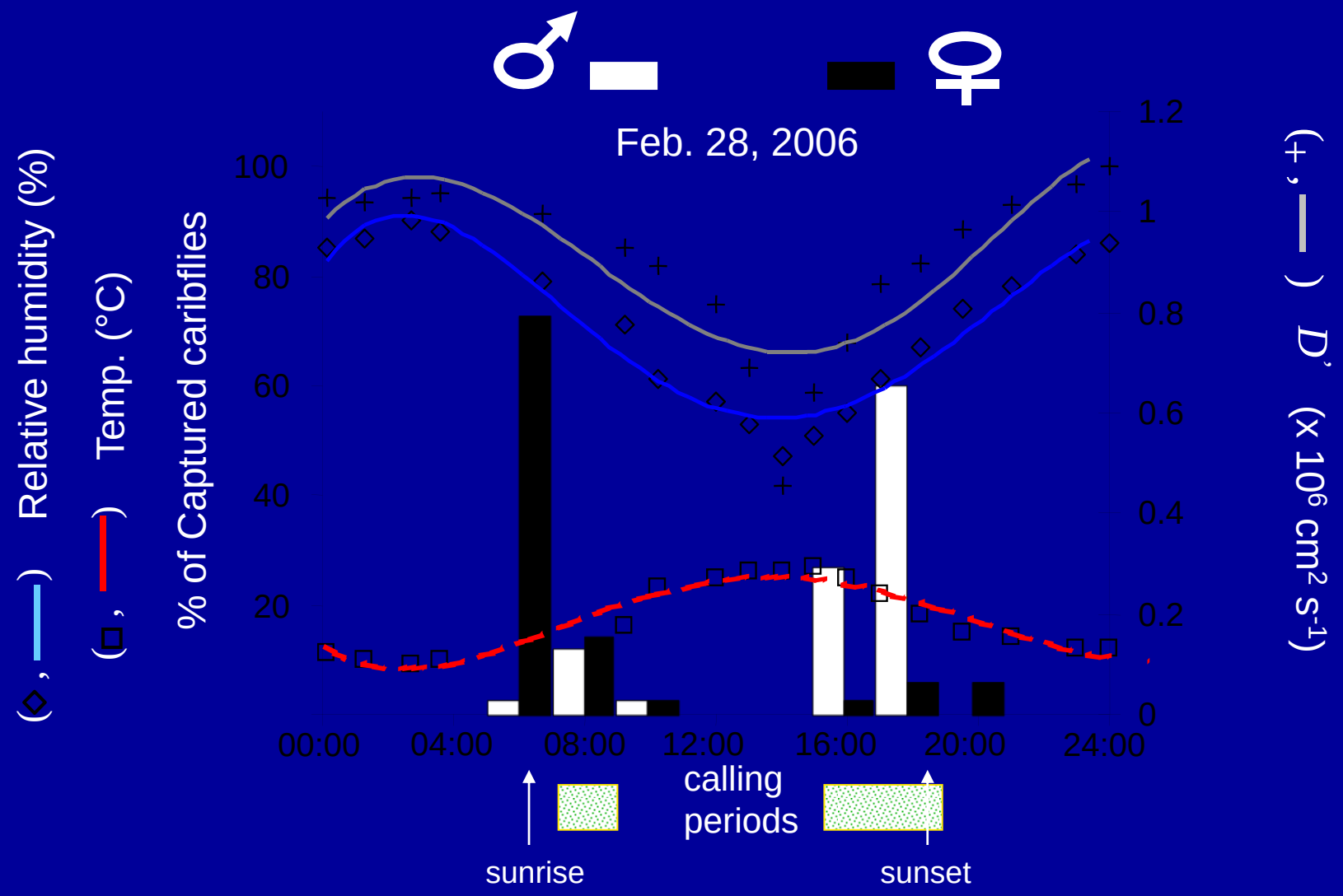
Design of pheromone release matrices: *abiotic exploitation >>>>>>> biotic exploitation*



Design of pheromone release matrices: water & diffusion driven