M E M O R A N D U M

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SUBJECT: LINEARITY OF CHLOROPICRIN BUFFER ZONE DISTANCES WITH FLUX

Summary. Chloropicrin buffer zone distances are linearly related to flux, except possibly near the low end of flux where modeling artifacts/minimum required buffer zones affect the relationship. In general, it appears that an x% reduction in flux results in *at least* an x% reduction in buffer zones. This implies that a system of buffer zone credits based on a percentage of flux reduction may apply over different application rates or acreages.

Introduction. The relationship between buffer zone distances and flux reductions is important in order to assess the possibility of providing 'credits' to buffer zone distances based on demonstrated flux reduction techniques. Extensive buffer zone calculation results were provided in Barry (2014). She calculated buffer zones using the PERFUM model (Reiss and Griffin 2006) with 5 different meteorological data sets, each being 5 years long and representative of major agricultural regions in California. The buffer zone criteria were consistent in all cases: the 95th percentile, maximum direction. Nine application methods were simulated. Each method was simulated over the 5 meteorological data sets, giving a total of 45 tables. For each meteorological data set/method combination, a table consisted of buffer zones for each combination of application rates of 100, 150, 200, 250, 300 and 350 lbs/acre and acreages of 1, 5, 10, 20, 30 and 40 acres. This set of buffer zone tables provides a data set which can be analyzed to test the linearity between buffer zone distances and flux. It is not the intent of this memorandum to calculate actual buffer zones, but to determine if the procedures used to calculate buffer zones based on the consistent criteria used by Barry (2014) estimate buffer zones that exhibit linear behavior as a function of flux.

Methods. From the 45 possible combinations of methods and meteorology, 7 combinations were chosen to span a variety of application techniques and at least one set from each of the 5 meteorological regions. The 7 combinations chosen were: poly drip Monterey, poly broadcast

Manteca - San Joaquin County

	app size (ac)					
app rate (lb/ac)	1	5	10	20	30	40
100	0	0	0	16	16	16
150	0	16	16	16	16	16
200	0	16	16	40	69	92
250	16	16	59	116	157	193
300	16	59	117	191	259	301
350	16	100	169	267	344	413

Table 1. Example buffer zone table excerpted from Barry (2014) showing application rate (lbs/ac), field size (acre) and buffer zone (feet) based on PERFUM calculations using a 95% maximum direction criterion.

Manteca, poly bed Tulelake, poly strip Belridge, untarp drip Ventura, untarp bed shallow Ventura, strip tif Ventura. For each of the 7 combinations selected, regressions on buffer zone distance versus application rate for each of the 6 acreages were performed. Table 1 is excerpted from Barry (2014) and shows the buffer zone calculations for poly broadcast with Manteca weather. This table yielded six regressions, each regression based on acreage. For example, the buffer zone distances for a 40 acre field (y value) were regressed on the application rates (x value).

An important assumption of this analysis is the linear relationship between application rate and flux. CDPR has a long standing assumption that if an application at a rate of x pounds per acre yields a flux of F, then an application rate of kx pounds per acre will yield a flux of kF, where k is some positive number (Segawa 1997). This assumption is embedded in the PERFUM procedure which calculates buffer zones at various application rates by multiplying the flux by corresponding factor. Barry (2014) regressed the flux from 15 poly tarp chloropicrin applications on the associated application rate and found a strong linear relationship (Barry 2014, Figure 8). The linear relationship between application rate and flux obviates the need to explicitly use flux in the regression analysis because flux is implicit in the application rate and has already been taken into account vis a vis the PERFUM modeling. Therefore, in assessing the linearity of the relationship between flux and buffer zone distance, it is acceptable to use the application rate as a meaningful proxy for flux.

Results. The relationships between buffer zone distance and application rate were substantially linear in almost all cases (Figure 1). In some cases, such as the Poly Drip Broadcast Manteca, the lower application rates gave results which were 0 or 16 feet, resulting in a bend in that region of the chart (30 and 40 acre lines). The scaling of the vertical axis for the higher acreages tended to compress the vertical changes in the lines from the 1 and 5 acre plots.

Regression analysis was performed on all acreages within each of the 7 application x meteorological combinations (Table 2). One regression (Poly Drip Broadcast Monterey 1 acre) was not significant ($p>0.5$). The remaining regressions were significant ($p<.05$). Regressions for larger acreages and for methods with higher fluxes (based on longer buffer zones compared to other methods), generally had higher r2 values.

For each acreage line within each combination, the regression constants were used to estimate buffer zone length near the middle range of application rates and at the upper end of application rates. These estimates were used to calculate the effect of a 15% reduction in the application rate on the buffer zone distance.

For the mid-range calculations, the change in application rate was -15.2%. That is, reducing the application rate from 243.5 lbs/ac to 206.5 lbs/ac At each of those two application rates, the buffer zone was estimated using the slope and intercept for that acreage analysis. For example, for Poly drip Monterey 5 acres, the slope is 1.04 and the intercept is -121. The estimated buffer zone at 243.5 lbs/ac is 132.2 feet and at 206.5 lbs/ac is 93.8 feet. This results in -29.1% change in the buffer zone, from 132.2 to 93.8 (-29.1%=100*(93.8-132.2)/132.2). In this case, a 15.2% reduction in application rate (flux) leads to an estimated 29.1% reduction in the buffer zone distance. Calculations at the upper range are similarly organized in Table 2 and show the estimated impact of a 15.1 reduction in the application rate (or flux) at the upper range of application rates.

In all cases the 15% reduction in application rate resulted in at least a 15% reduction in the buffer zone length.

Summary. Buffer zone distances for chloropicrin determined by using PERFUM with the consistent policy of 95% percentile maximum direction estimated buffer zones were highly linearly related to flux (or application rate). In all cases examined, the percentage decrease in buffer zones was at least as large as the percentage decrease in flux. These calculations are not intended as a method to estimate buffer zones, but rather to demonstrate that there appears to be a highly linear relationship between buffer zone distance and flux.

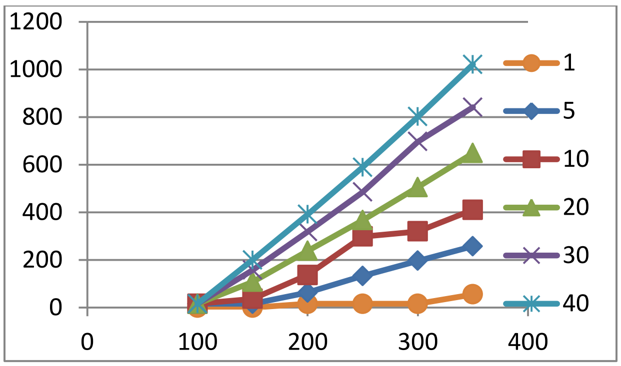
References

Barry, Terrell. 2014. Memorandum to David Duncan on "Development of Chloropicrin Buffer Zones – Revised" dated October 31, 2014.

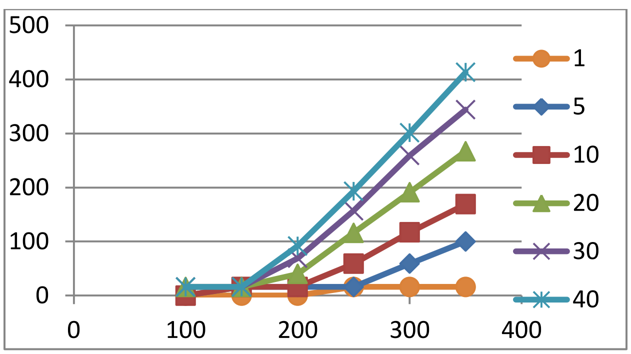
Riess, R and J. Griffin. 2006. A probabilistic model for acute bystander exposure and risk assessments for soil fumigants. Atmospheric Environment 40(19):3548-3560.

Segawa, Randy. 1997. Memorandum to John Sanders dated September 4, 1997 on description of computer modeling procedures for methyl bromide. http://www.cdpr.ca.gov/docs/emon/methbrom/em9703.htm

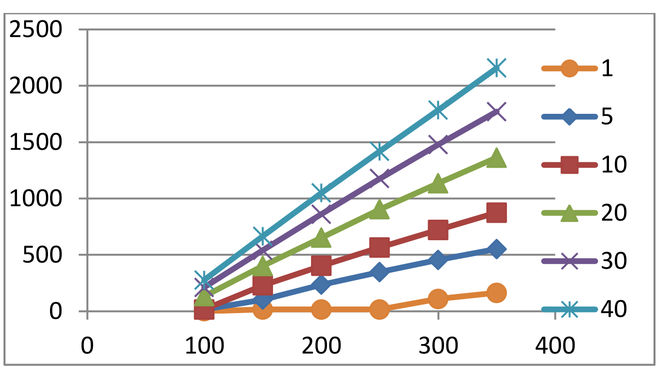
Figure 1. Seven meteorology and application combinations chosen for analysis. In all charts, the horizontal axis is application rate (lbs/acre) and the vertical axis is buffer zone distance (ft). The different lines represent different acreages, for example 1 acre or 5 acres, etc.



Poly Drip Monterey

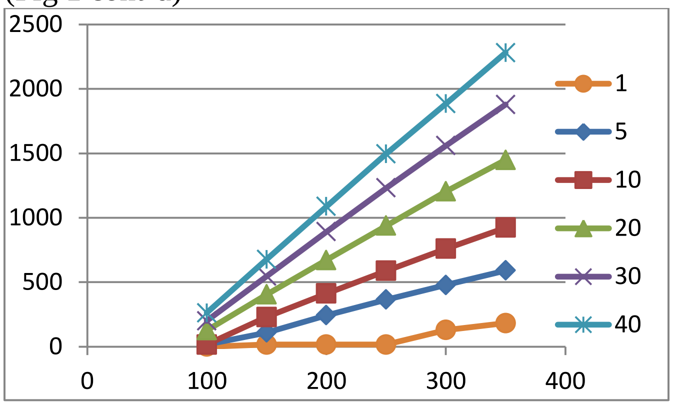


Poly Drip Broadcast Manteca

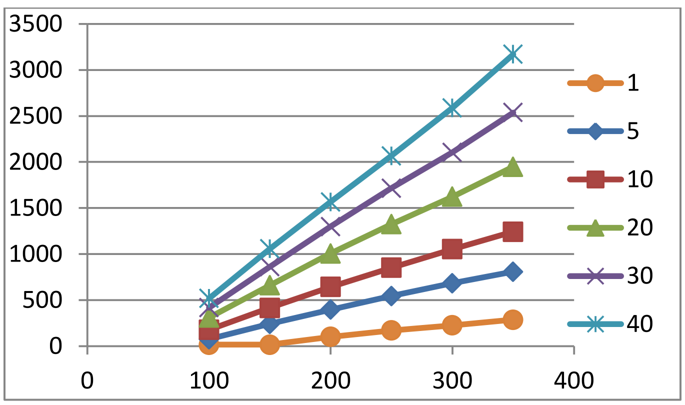


Poly Bed Tulelake

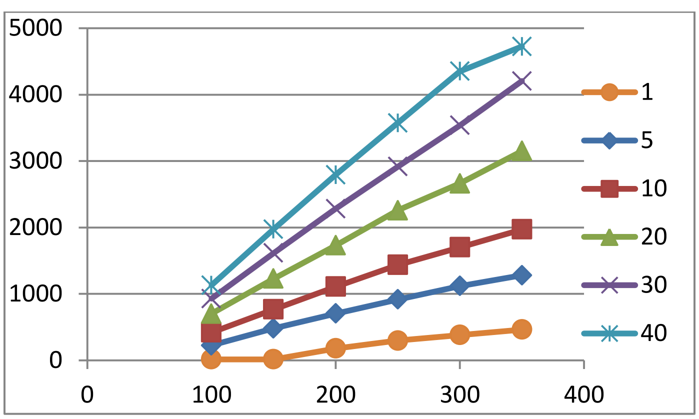
(Fig 1 cont'd)



Poly Strip Belridge

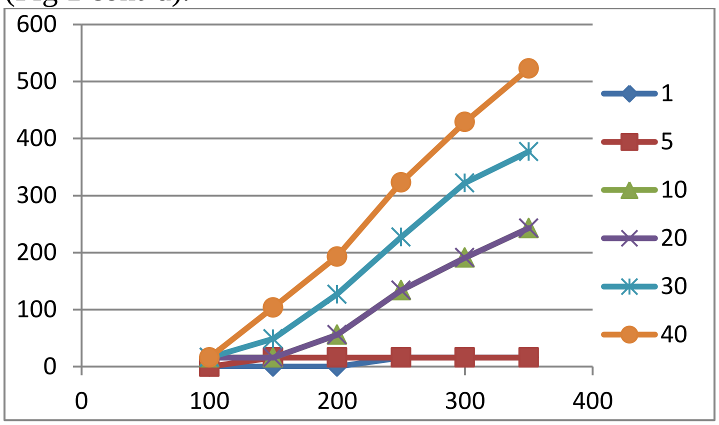


Untarp Drip Ventura

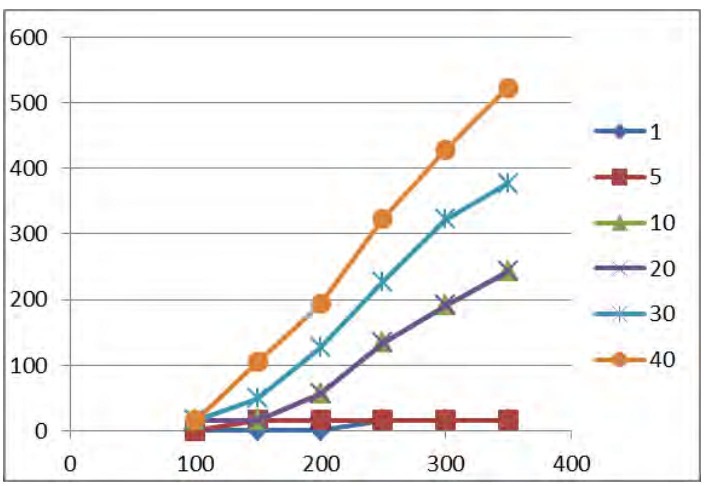


Untarp Bed Shallow Ventura

(Fig 1 cont'd).



TIF Strip Shallow Ventura



Strip TIF Ventura

Table 2. Regression results for the seven chosen application types and meteorology. Regression coefficients used to estimate buffer zones near the application rate midpoint and near the upper application rate range of a 15% reduction in application rate (proxy flux). X1 and X2 are the application rates and Y1 and Y2 are the corresponding estimated buffer zones.

					Near Range Midpoint						Near Upper Range					
					Lower Point		Upper Point				Lower Point		Upper Point			
	Acreage	slope (ft/(lbs /acre))	intercept (ft)	r2	x1 (lbs/ac)	y1 (ft)	x2 (lbs/ac)	y2 (ft)	% change in app rate (flux)	% change in buffer zone	x1 (lbs/ac)	y1 (ft)	x2 (lbs/ac)	y2 (ft)	% change in app rate (flux)	% change in buffer zone
Poly drip Monterey	1	ns	na	na												
	5	1.04	-121	94	206.5	93.8	243.5	132.2	-15.2	-29.1	297.0	187.9	350.0	243.0	-15.1	-22.7
	10	1.71	-181	95	206.5	172.1	243.5	235.4	-15.2	-26.9	297.0	326.9	350.0	417.5	-15.1	-21.7
	20	2.56	-263	99	206.5	265.6	243.5	360.4	-15.2	-26.3	297.0	497.3	350.0	633.0	-15.1	-21.4
	30	3.38	-340	99	206.5	358.0	243.5	483.0	-15.2	-25.9	297.0	663.9	350.0	843.0	-15.1	-21.3
	40	4.02	-401	99	206.5	429.1	243.5	577.9	-15.2	-25.7	297.0	792.9	350.0	1006.0	-15.1	-21.2
Poly broadcast Manteca	1	0.082	-10.5	71	206.5	6.4	243.5	9.5	-15.2	-32.0	297.0	13.9	350.0	18.2	-15.1	-23.9
	5	0.359	-46.4	74	206.5	27.7	243.5	41.0	-15.2	-32.4	297.0	60.2	350.0	79.3	-15.1	-24.0
	10	0.681	-90	87	206.5	50.6	243.5	75.8	-15.2	-33.2	297.0	112.3	350.0	148.4	-15.1	-24.3
	20	1.06	-131	89	206.5	87.9	243.5	127.1	-15.2	-30.9	297.0	183.8	350.0	240.0	-15.1	-23.4
	30	1.4	-172	92	206.5	117.1	243.5	168.9	-15.2	-30.7	297.0	243.8	350.0	318.0	-15.1	-23.3
	40	1.68	-206	94	206.5	140.9	243.5	203.1	-15.2	-30.6	297.0	293.0	350.0	382.0	-15.1	-23.3
Poly bed Tulelake	1	0.625	-87	72	206.5	42.1	243.5	65.2	-15.2	-35.5	297.0	98.6	350.0	131.8	-15.1	-25.1
	5	2.2	-210	99	206.5	244.3	243.5	325.7	-15.2	-25.0	297.0	443.4	350.0	560.0	-15.1	-20.8
	10	3.39	-294	99	206.5	406.0	243.5	531.5	-15.2	-23.6	297.0	712.8	350.0	892.5	-15.1	-20.1
	20	4.91	-340	99	206.5	673.9	243.5	855.6	-15.2	-21.2	297.0	1118.3	350.0	1378.5	-15.1	-18.9
	30	6.24	-398	99	206.5	890.6	243.5	1121.4	-15.2	-20.6	297.0	1455.3	350.0	1786.0	-15.1	-18.5
	40	7.51	-463	99	206.5	1087.8	243.5	1365.7	-15.2	-20.3	297.0	1767.5	350.0	2165.5	-15.1	-18.4
Poly strip Belridge	1	0.718	-101	71	206.5	47.3	243.5	73.8	-15.2	-36.0	297.0	112.2	350.0	150.3	-15.1	-25.3
	5	2.34	-227	99	206.5	256.2	243.5	342.8	-15.2	-25.3	297.0	468.0	350.0	592.0	-15.1	-20.9
	10	3.6	-322	99	206.5	421.4	243.5	554.6	-15.2	-24.0	297.0	747.2	350.0	938.0	-15.1	-20.3
	20	5.3	-393	99	206.5	701.5	243.5	897.6	-15.2	-21.8	297.0	1181.1	350.0	1462.0	-15.1	-19.2
	30	6.72	-461	99	206.5	926.7	243.5	1175.3	-15.2	-21.2	297.0	1534.8	350.0	1891.0	-15.1	-18.8
	40	8.07	-535	99	206.5	1131.5	243.5	1430.0	-15.2	-20.9	297.0	1861.8	350.0	2289.5	-15.1	-18.7
Untarp drip Ventura	1	1.178	-128	96	206.5	115.3	243.5	158.8	-15.2	-27.4	297.0	221.9	350.0	284.3	-15.1	-22.0
	5	2.93	-202	99	206.5	403.0	243.5	511.5	-15.2	-21.2	297.0	668.2	350.0	823.5	-15.1	-18.9
	10	4.26	-220	99	206.5	659.7	243.5	817.3	-15.2	-19.3	297.0	1045.2	350.0	1271.0	-15.1	-17.8
	20	6.52	-321	99	206.5	1025.4	243.5	1266.6	-15.2	-19.0	297.0	1615.4	350.0	1961.0	-15.1	-17.6
	30	8.42	-406	99	206.5	1332.7	243.5	1644.3	-15.2	-18.9	297.0	2094.7	350.0	2541.0	-15.1	-17.6
	40	10.5	-532	99	206.5	1636.3	243.5	2024.8	-15.2	-19.2	297.0	2586.5	350.0	3143.0	-15.1	-17.7
Untarp bed shallow Ventura	1	1.98	-219	96	206.5	189.9	243.5	263.1	-15.2	-27.8	297.0	369.1	350.0	474.0	-15.1	-22.1
	5	4.23	-163	99	206.5	710.5	243.5	867.0	-15.2	-18.1	297.0	1093.3	350.0	1317.5	-15.1	-17.0
	10	6.23	-166	99	206.5	1120.5	243.5	1351.0	-15.2	-17.1	297.0	1684.3	350.0	2014.5	-15.1	-16.4
	20	9.75	-238	99	206.5	1775.4	243.5	2136.1	-15.2	-16.9	297.0	2657.8	350.0	3174.5	-15.1	-16.3
	30	13	-348	99	206.5	2336.5	243.5	2817.5	-15.2	-17.1	297.0	3513.0	350.0	4202.0	-15.1	-16.4
	40	14.8	-237	99	206.5	2819.2	243.5	3366.8	-15.2	-16.3	297.0	4158.6	350.0	4943.0	-15.1	-15.9
Strip tif Ventura	1	0.0823	-10.5	71	206.5	6.5	243.5	9.5	-15.2	-31.9	297.0	13.9	350.0	18.3	-15.1	-23.8
	5	0.354	-46	69	206.5	27.1	243.5	40.2	-15.2	-32.6	297.0	59.1	350.0	77.9	-15.1	-24.1
	10	0.765	-104	84	206.5	54.0	243.5	82.3	-15.2	-34.4	297.0	123.2	350.0	163.8	-15.1	-24.8
	20	1.29	-166	88	206.5	100.4	243.5	148.1	-15.2	-32.2	297.0	217.1	350.0	285.5	-15.1	-23.9
	30	1.77	-222	92	206.5	143.5	243.5	209.0	-15.2	-31.3	297.0	303.7	350.0	397.5	-15.1	-23.6
	40	2.14	-266	94	206.5	175.9	243.5	255.1	-15.2	-31.0	297.0	369.6	350.0	483.0	-15.1	-23.5