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RISK QUOTIENTS

In this section we develop four avian exposure profiles (scenarios) that will capture the range of exposures likely to occur and will allow for a comprehensive risk characterization. Based on the foregoing information and analysis, there are three components to each of these scenarios: how chlorfenapyr is applied; the usage of cotton fields by birds; and the amount of residue on seeds, insects or fruits. The first component of each scenario is the use pattern. Two use patterns are assumed. One is an early season application made to Western Cotton to control mites. This application is made by ground equipment at the rate of 0.15 lb. a.i./A. The second use pattern is late season application to Southern and Western Cotton for control of worms. Two applications totaling 0.5 lb. a.i./A will be made by air.

The second component of each scenario is bird usage of cotton fields. For the purposes of this assessment, we have defined three levels for bird usage of the cotton agroenvironment. In the "high exposure" level, birds are assumed to forage 100% of the time on the treated field. In the "moderate exposure" level, birds are assumed to forage 50% of the time in the treated field and 50% of the time in the field border. The borders are assumed to be 0 - 50 feet for ground application and 0 - 150 feet for aerial application. In the "low exposure" level, birds are assumed to forage 100% of the time in the 0 - 50 or 0 - 150 foot borders. Based on information from field studies, we feel that the high exposure level is a reasonable worst case, and that the moderate exposure level is biased to overestimate actual exposure.

The third component of each scenario is the amounts of residue on seeds, insects, or fruits, and their degradation over time. Values were obtained for these food items on the treated field as well as in the 0 - 50 or 0 - 150 borders. Residue levels were determined for the day after application and, to factor in degradation of chlorfenapyr in the environment, 10 days after application. The residue value for seeds on the treated field was obtained from the Weed Seed Study, **Table 6.** The residue value on day one after three weekly applications totaling 0.54 lb. a.i./A was 16.3 ppm. This value reflects the current label that allows multiple applications at 5 - 7 day intervals totaling 0.5 lb. a.i./A. The residue value of 0.12 ppm for weed seeds off the treated field was obtained by averaging the day 0.1 values from the four MS EUP studies (See **Table 6**) and dividing by two to reflect the current 0.5 lb. a.i./A limit. Surprisingly, the average values over the three intervals (0 - 10, 10 -25, and 25- 50 feet for ground and 0 - 25, 25 - 75, and 75 - 150 for air) were virtually identical, so values for air and ground applications were pooled. The ratio between the weed seed residue on the field, 16.3 ppm, and the value off the field, 0.12 ppm provided a lower limit for matrices where off field residues were not available. Residues in insects were 4.15 ppm, which is the average of 5.71 ppm from the Small Scale Exposure Study and the maximum day 0.1 residues from the Insect Field Study (see **Table 7**) for moths, 4.25 ppm, and larvae, 2.48 ppm. Residue levels in insects off the treated field were set at one-tenth of the residue levels of insects on the treated field, 0.41 ppm. This value is conservative compared to the over 100-fold difference between weed residues on and off the treated field. The residue value for fruits, 0.5 ppm, was obtained by averaging values for grapes, strawberries, and tomatoes from the table on residues in raw agricultural commodities. Because no data were available for residues in fruits off the treated field, a one-tenth factor was used.

Scenario 1 is applicable to both Southern and Western cotton and assumes multiple applications totaling 0.5 lb. a.i./A have been made to a field. It assumes the final application was made between early to mid-July through mid-September; and the birds are present shortly after the final application when residues are at their maximum. Three levels of exposure represent birds feeding solely on the treated field, splitting their time equally between the treated field and the area immediately adjacent (up to 150 ft), or feeding solely in the adjacent area. For "on the field", the seed residue value was taken for Day 1 for the treatments in the Weed Seed Study that totaled 0.54 lb. a.i./A, and the off-field value was determined by averaging all the values from Day 0.1 for each distance category for both aerial and ground applications and dividing this value by 2, since the total amount applied in each of the four Mississippi studies totaled 1.05 lb. a.i./A. For insects on the field, the highest mean residue values for moths (from the 0.20 lb. a.i./A treatment) and larvae (from the 0.35 lb. a.i./A treatment) were averaged with the Day 0.1 on-field insects (from the 0.4 lb. a.i./A treatment) from the Georgia Small Scale Exposure Study. The off-field insects were estimated to be 10% of the on-field insects. The on-field fruit values were the average of the time zero residue values for strawberries, grapes and tomatoes. The off-field fruit residue values were 10% of the on-field value.

Scenario 2 is also applicable to both Southern and Western cotton and assumes multiple applications have been made to a field totaling 0.5 lb. a.i./A. It also assumes the final application was made between early to mid-July through mid-September; however, it assumes the residues have degraded for ten days prior to birds visiting the field. The same three levels of exposure are assumed. The seed degradation half-life is assumed to be approximately ten days from **Table 6**, so both on-field and off-field seed residue values are half those presented in Scenario 1. The half-life for degradation of insect residues is assumed to be less than three days, so insect residues are assumed to degrade to negligible amounts. The half-lives from the fruit residue studies ranged from 3 to 27 days with a mean average half-life of 11.5 days, so the fruit residues were assumed to degrade by approximately one-half.

Scenario 3 is applicable only to Western Cotton and assumes a single application at 0.15 lb. a.i./A. It assumes the application was made prior to early July and the birds are present shortly after the application when residues are at their maximum. The same three levels of exposure are presented. For on the field, the seed residue value from Scenario 1 was adjusted linearly downward from an application of 0.5 lb. a.i./A to 0.15 a.i./A (factor of 0.3) because no on-field seed data were available for this rate. For seeds off the field, the residue level was set at 0.05 ppm; this is greater than would be calculated from the observed 100-fold difference between weed residues on and off the field noted for Scenario 1. For insects on the field, the mean residue values for Day 0.1 moths and larvae from the 0.2 lb. a.i./A from the Insect Residue Study were averaged with the Day 0.1 on-field insects (from the 0.2 lb. a.i./A treatment) from the Georgia Small Scale Exposure Study. The off-field insects were estimated to be 10% of the on-field insects. The on-field fruit values derived by multiplying the fruit residue values in Scenario 1 by 0.3. The off-field fruit residue values were set at 0.05, again, greater than expected from the observed 100-fold difference between weed residues on and off the field noted for Scenario 1.

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Scenario 4 is also only applicable to Western cotton. It again assumes the residues from Scenario 3 have degraded for ten days prior to birds visiting the field. The same degradation half-lives that were used to create Scenario 2 from Scenario 1 were applied to create Scenario 4 from Scenario 3.

Acute RQs - Southern Cotton

Acute Oral Risk Quotients Scenario 1: Immediately following last late season application, total of 0.5 lb. a.i./A

Species	Exposure Level	Total mg/kg/day	LD_{50}	Acute Oral RQ
Carolina Wren	High	2.336	2.2	1.062
	Moderate	1.283	2.2	0.583
	Low	0.231	2.2	0.105
White-eyed Vireo	High	2.427	2.2	1.103
	Moderate	1.333	2.2	0.606
	Low	0.240	2.2	0.109
Northern Cardinal	High	1.128	2.2	0.513
	Moderate	0.617	2.2	0.281
	Low	0.107	2.2	0.049
Blue Grosbeak	High	1.282	2.2	0.583
	Moderate	0.685	2.2	0.311
	Low	0.088	2.2	0.040
Mourning Dove	High	0.983	34	0.029
	Moderate	0.495	34	0.015
	Low	0.007	34	0.000
Red-winged Blackbird	High	1.078	2.2	0.490
	Moderate	0.571	2.2	0.260
	Low	0.064	2.2	0.029
Mallard Duck	High	0.001	10.3	<0.001
	Moderate	<0.001	10.3	<0.001
	Low	<0.001	10.3	<0.001

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Acute Oral Risk Quotients Scenario 2: ten days after last late season application

Species	Exposure Level	Total mg/kg/day	LD_{50}	Acute Oral RQ
Carolina Wren	High	0.0015	2.2	0.001
	Moderate	0.0008	2.2	0.000
	Low	0.0000	2.2	0.000
White-eyed Vireo	High	0.0026	2.2	0.001
	Moderate	0.0015	2.2	0.001
	Low	0.0003	2.2	0.000
Northern Cardinal	High	0.0290	2.2	0.013
	Moderate	0.0148	2.2	0.007
	Low	0.0007	2.2	0.000
Blue Grosbeak	High	0.2139	2.2	0.097
	Moderate	0.1077	2.2	0.049
	Low	0.0016	2.2	0.001
Mourning Dove	High	0.4936	34	0.015
	Moderate	0.2486	34	0.007
	Low	0.0036	34	0.000
Red-winged Blackbird	High	0.2319	2.2	0.105
	Moderate	0.1168	2.2	0.053
	Low	0.0017	2.2	0.001

Acute Dietary Risk Quotients Scenario 1: immediately following last late season application

Species	Exposure Level	Total mg/kg/day	LC_{50}	Acute Dietary RQ
Carolina Wren	High	4.406	11.3	0.390
	Moderate	2.398	11.3	0.212
	Low	0.391	11.3	0.035
White-eyed Vireo	High	3.785	11.3	0.335
	Moderate	2.080	11.3	0.184
	Low	0.374	11.3	0.033
Northern Cardinal	High	5.387	11.3	0.477
	Moderate	2.851	11.3	0.252
	Low	0.316	11.3	0.028
Blue Grosbeak	High	9.022	11.3	0.798
	Moderate	4.658	11.3	0.412
	Low	0.294	11.3	0.026
Mourning Dove	High	16.208	132	0.123
	Moderate	8.166	132	0.062
	Low	0.123	132	0.001
Red-winged Blackbird	High	9.631	11.3	0.852
	Moderate	4.955	11.3	0.439
	Low	0.280	11.3	0.025
Mallard Duck	High	0.007	8.6	0.001
	Moderate	0.004	8.6	<0.001
	Low	0.001	8.6	<0.001

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Acute Dietary Risk Quotients Scenario 2 Ten days after last late season application

Species	Exposure Level	Total mg/kg/day	LC_{50}	Acute Dietary RQ
Carolina Wren	High	0.254	11.3	0.022
	Moderate	0.128	11.3	0.011
	Low	0.003	11.3	0.000
White-eyed Vireo	High	0.025	11.3	0.002
	Moderate	0.014	11.3	0.001
	Low	0.003	11.3	0.000
Northern Cardinal	High	1.225	11.3	0.108
	Moderate	0.619	11.3	0.055
	Low	0.013	11.3	0.001
Blue Grosbeak	High	3.280	11.3	0.290
	Moderate	1.652	11.3	0.146
	Low	0.024	11.3	0.002
Mourning Dove	High	8.118	132	0.062
	Moderate	4.089	132	0.031
	Low	0.059	132	0.000
Red-winged Blackbird	High	3.690	11.3	0.327
	Moderate	1.859	11.3	0.164
	Low	0.027	11.3	0.002

Chronic RQs - Southern Cotton

Scenario 1: Time Zero Residues

Species	Exposure Level	Total ppm	Reproduction NOEC	Chronic Reproduction RQ
Carolina Wren	High	4.406	0.5	8.81
	Moderate	2.398	0.5	4.80
	Low	0.391	0.5	0.78
White-eyed Vireo	High	3.785	0.5	7.57
	Moderate	2.080	0.5	4.16
	Low	0.374	0.5	0.75
Northern Cardinal	High	5.387	0.5	10.77
	Moderate	2.851	0.5	5.70
	Low	0.316	0.5	0.63
Blue Grosbeak	High	9.022	0.5	18.04
	Moderate	4.658	0.5	9.32
	Low	0.294	0.5	0.59
Mourning Dove	High	16.208	1.5	10.81
	Moderate	8.166	1.5	5.44
	Low	0.123	1.5	0.08
Red-winged Blackbird	High	9.631	0.5	19.26
	Moderate	4.955	0.5	9.91
	Low	0.280	0.5	0.56

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Scenario 2: Residues Ten Days After Application

Species	Exposure Level	Total ppm	Reproduction NOEC	Chronic Reproduction RQ
Carolina Wren	High	0.254	0.5	0.51
	Moderate	0.128	0.5	0.26
	Low	0.003	0.5	0.01
White-eyed Vireo	High	0.025	0.5	0.05
	Moderate	0.014	0.5	0.03
	Low	0.003	0.5	0.01
Northern Cardinal	High	1.225	0.5	2.45
	Moderate	0.619	0.5	1.24
	Low	0.013	0.5	0.03
Blue Grosbeak	High	3.280	0.5	6.56
	Moderate	1.652	0.5	3.30
	Low	0.024	0.5	0.05
Mourning Dove	High	8.118	1.5	5.41
	Moderate	4.089	1.5	2.73
	Low	0.059	1.5	0.04
Red-winged Blackbird	High	3.690	0.5	7.38
	Moderate	1.859	0.5	3.72
	Low	0.027	0.5	0.05

Acute RQs - Western Cotton

Acute Oral Risk Quotients Scenario 1 Immediately following last late season application

Species	Exposure Level	Total mg/kg/day	LD_{50}	Acute Oral RQ
Carolina Wren	High	2.336	2.2	1.062
	Moderate	1.283	2.2	0.583
	Low	0.231	2.2	0.105
White-eyed Vireo	High	2.427	2.2	1.103
	Moderate	1.333	2.2	0.606
	Low	0.240	2.2	0.109
Northern Cardinal	High	1.128	2.2	0.513
	Moderate	0.617	2.2	0.281
	Low	0.107	2.2	0.049
Blue Grosbeak	High	1.282	2.2	0.583
	Moderate	0.685	2.2	0.311
	Low	0.088	2.2	0.040
Mourning Dove	High	0.983	34	0.029
	Moderate	0.495	34	0.015
	Low	0.007	34	0.000
Red-winged Blackbird	High	1.078	2.2	0.490
	Moderate	0.571	2.2	0.260
	Low	0.064	2.2	0.029
Mallard Duck	High	0.001	10.3	<0.001
	Moderate	<0.001	10.3	<0.001
	Low	<0.001	10.3	<0.001

Acute Oral Risk Quotients Scenario 2 Ten days after last late season application

Species	Exposure Level	Total mg/kg/day	LD_{50}	Acute Oral RQ
Carolina Wren	High	0.0015	2.2	0.001
	Moderate	0.0008	2.2	0.000
	Low	0.0000	2.2	0.000
White-eyed Vireo	High	0.0026	2.2	0.001
	Moderate	0.0015	2.2	0.001
	Low	0.0003	2.2	0.000
Northern Cardinal	High	0.0290	2.2	0.013
	Moderate	0.0148	2.2	0.007
	Low	0.0007	2.2	0.000
Blue Grosbeak	High	0.2139	2.2	0.097
	Moderate	0.1077	2.2	0.049
	Low	0.0016	2.2	0.001
Mourning Dove	High	0.4936	34	0.015
	Moderate	0.2486	34	0.007
	Low	0.0036	34	0.000
Red-winged Blackbird	High	0.2319	2.2	0.105
	Moderate	0.1168	2.2	0.053
	Low	0.0017	2.2	0.001

Acute Dietary Risk Quotients Scenario 1 Immediately following last late season application

Species	Exposure Level	Total mg/kg/day	LC_{50}	Acute Dietary RQ
Carolina Wren	High	4.406	11.3	0.390
	Moderate	2.398	11.3	0.212
	Low	0.391	11.3	0.035
White-eyed Vireo	High	3.785	11.3	0.335
	Moderate	2.080	11.3	0.184
	Low	0.374	11.3	0.033
Northern Cardinal	High	5.387	11.3	0.477
	Moderate	2.851	11.3	0.252
	Low	0.316	11.3	0.028
Blue Grosbeak	High	9.022	11.3	0.798
	Moderate	4.658	11.3	0.412
	Low	0.294	11.3	0.026
Mourning Dove	High	16.208	132	0.123
	Moderate	8.166	132	0.062
	Low	0.123	132	0.001
Red-winged Blackbird	High	9.631	11.3	0.852
	Moderate	4.955	11.3	0.439
	Low	0.280	11.3	0.025
Mallard Duck	High	0.007	8.6	0.001
	Moderate	0.004	8.6	<0.001
	Low	0.001	8.6	<0.001

Acute Dietary Risk Quotients Scenario 2 Ten days after last late season application

Species	Exposure Level	Total mg/kg/day	LC_{50}	Acute Dietary RQ
Carolina Wren	High	0.254	11.3	0.022
	Moderate	0.128	11.3	0.011
	Low	0.003	11.3	0.000
White-eyed Vireo	High	0.025	11.3	0.002
	Moderate	0.014	11.3	0.001
	Low	0.003	11.3	0.000
Northern Cardinal	High	1.225	11.3	0.108
	Moderate	0.619	11.3	0.055
	Low	0.013	11.3	0.001
Blue Grosbeak	High	3.280	11.3	0.290
	Moderate	1.652	11.3	0.146
	Low	0.024	11.3	0.002
Mourning Dove	High	8.118	132	0.062
	Moderate	4.089	132	0.031
	Low	0.059	132	0.000
Red-winged Blackbird	High	3.690	11.3	0.327
	Moderate	1.859	11.3	0.164
	Low	0.027	11.3	0.002

Acute Oral Risk Quotients Scenario 3 Immediately following single early season mite application

Species	Exposure Level	Total mg/kg/day	LD_{50}	Acute Oral RQ
Carolina Wren	High	1.2152	2.2	0.552
	Moderate	0.6694	2.2	0.304
	Low	0.1237	2.2	0.008
White-eyed Vireo	High	1.2619	2.2	0.574
	Moderate	0.6954	2.2	0.316
	Low	0.1289	2.2	0.059
Northern Cardinal	High	0.5743	2.2	0.261
	Moderate	0.3160	2.2	0.144
	Low	0.0577	2.2	0.026
Blue Grosbeak	High	0.5733	2.2	0.261
	Moderate	0.3100	2.2	0.141
	Low	0.0467	2.2	0.021
Mourning Dove	High	0.2950	34	0.009
	Moderate	0.1490	34	0.004
	Low	0.0030	34	0.000
Red-winged Blackbird	High	0.4592	2.2	0.209
	Moderate	0.2466	2.2	0.112
	Low	0.0341	2.2	0.015

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Acute Oral Risk Quotients Scenario 4 Ten days after single early season mite application

Species	Exposure Level	Total mg/kg/day	LD_{50}	Acute Oral RQ
Carolina Wren	High	0.0005	2.2	0.000
	Moderate	0.0003	2.2	0.000
	Low	0.0000	2.2	0.000
White-eyed Vireo	High	0.0008	2.2	0.000
	Moderate	0.0006	2.2	0.000
	Low	0.0003	2.2	0.000
Northern Cardinal	High	0.0089	2.2	0.004
	Moderate	0.0047	2.2	0.002
	Low	0.0006	2.2	0.000
Blue Grosbeak	High	0.0652	2.2	0.030
	Moderate	0.0330	2.2	0.015
	Low	0.0008	2.2	0.000
Mourning Dove	High	0.1505	34	0.004
	Moderate	0.0761	34	0.002
	Low	0.0018	34	0.000
Red-winged Blackbird	High	0.0707	2.2	0.032
	Moderate	0.0358	2.2	0.016
	Low	0.0008	2.2	0.000

Acute Dietary Risk Quotients Scenario 3 Immediately following single early season mite application

Species	Exposure Level	Total mg/kg/day	LC_{50}	Acute Dietary RQ
Carolina Wren	High	2.182	11.3	0.193
	Moderate	1.196	11.3	0.106
	Low	0.210	11.3	0.019
White-eyed Vireo	High	1.959	11.3	0.173
	Moderate	1.081	11.3	0.096
	Low	0.203	11.3	0.018
Northern Cardinal	High	2.266	11.3	0.201
	Moderate	1.218	11.3	0.108
	Low	0.171	11.3	0.015
Blue Grosbeak	High	3.256	11.3	0.288
	Moderate	1.704	11.3	0.151
	Low	0.152	11.3	0.013
Mourning Dove	High	4.873	132	0.037
	Moderate	2.462	132	0.019
	Low	0.052	132	0.000
Red-winged Blackbird	High	3.393	11.3	0.300
	Moderate	1.768	11.3	0.156
	Low	0.144	11.3	0.013

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Acute Dietary Risk Quotients Scenario 4 Ten days after single early season mite application

Species	Exposure Level	Total mg/kg/day	LC_{50}	Acute Dietary RQ
Carolina Wren	High	0.077	11.3	0.007
	Moderate	0.040	11.3	0.004
	Low	0.002	11.3	0.000
White-eyed Vireo	High	0.008	11.3	0.001
	Moderate	0.006	11.3	0.000
	Low	0.003	11.3	0.000
Northern Cardinal	High	0.374	11.3	0.033
	Moderate	0.191	11.3	0.017
	Low	0.009	11.3	0.001
Blue Grosbeak	High	1.000	11.3	0.088
	Moderate	0.506	11.3	0.045
	Low	0.012	11.3	0.001
Mourning Dove	High	2.475	132	0.019
	Moderate	1.252	132	0.009
	Low	0.030	132	0.000
Red-winged Blackbird	High	1.125	11.3	0.100
	Moderate	0.569	11.3	0.050
	Low	0.014	11.3	0.001

Chronic RQs Western Cotton

Scenario 3: Time Zero Residues

Species	Exposure Level	Total ppm	Reproduction NOEC	Chronic Reproduction RQ
Carolina Wren	High	2.182	0.5	4.36
	Moderate	1.196	0.5	2.39
	Low	0.210	0.5	0.42
White-eyed Vireo	High	1.959	0.5	3.918
	Moderate	1.081	0.5	2.16
	Low	0.203	0.5	0.406
Northern Cardinal	High	2.266	0.5	4.53
	Moderate	1.218	0.5	2.44
	Low	0.171	0.5	0.34
Blue Grosbeak	High	3.256	0.5	6.51
	Moderate	1.704	0.5	3.41
	Low	0.152	0.5	0.30
Mourning Dove	High	4.873	1.5	3.25
	Moderate	2.462	1.5	1.64
	Low	0.052	1.5	0.03
Red-winged Blackbird	High	3.393	0.5	6.79
	Moderate	1.768	0.5	3.54
	Low	0.144	0.5	0.29

Scenario 4: Residues Ten Days After Application

Species	Exposure Level	Total ppm	Reproduction NOEC	Chronic Reproduction RQ
Carolina Wren	High	0.077	0.5	0.15
	Moderate	0.040	0.5	0.08
	Low	0.002	0.5	0.00
White-eyed Vireo	High	0.008	0.5	0.02
	Moderate	0.006	0.5	0.01
	Low	0.003	0.5	0.01
Northern Cardinal	High	0.374	0.5	0.75
	Moderate	0.191	0.5	0.38
	Low	0.009	0.5	0.02
Blue Grosbeak	High	1.000	0.5	2.00
	Moderate	0.506	0.5	1.01
	Low	0.012	0.5	0.02
Mourning Dove	High	2.475	1.5	1.65
	Moderate	1.252	1.5	0.83
	Low	0.030	1.5	0.02
Red-winged Blackbird	High	1.125	0.5	2.25
	Moderate	0.569	0.5	1.14
	Low	0.014	0.5	0.03

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1988 to 1996 Acreages Treated for Labeled Pests

An estimate of the extent of exposure of cotton agroecosystems to chlorfenapyr can be made as follows. Head (1989, 1990, 1991, 1992) and Williams (1993, 1994, 1995, 1996, 1997 in press) have published estimates of acreages infested at economic levels for budworm and bollworm, beet armyworm, fall armyworm, and mites. These values would represent the maximum acreage treated. Head and Williams also provide estimates of the number of treatments made per economically infested acre. An estimate of the number of treatment acres per year can be made by multiplying the number of acres with economic infestations by the number of applications per acre (Dr. M. R. Williams, Mississippi State University, personal communication).

Economically Infested Acreages (1988 - 1996) for Budworm and Bollworm on the Chlorfenapyr Label

Year	Budworm/ Bollworm	# of Applications
1988	6,715,292	1.5
1989	4,683,150	1.8
1990	6,063,315	1.6
1991	8,218,848	1.6
1992	5,917,902	2.2
1993	6,560,980	1.8
1994	7,316,227	1.9
1995	9,259,951	2.4
1996	6,269,592	1.32
Minimum	4,683,150	1.32
Average	6,764,362	2.0
Maximum	9,133,951	2.4

Economically Infested Acreages (1988 - 1996) for Armyworms on the Chlorfenapyr Label

Year	Beet Armyworm	# of Applications	Fall Armyworm	# of Applications
1989	529,996	0.1	170,336	0.1
1990	803,9750.2	0.1	319,195	0.1
1991	472,000	0.1	383,380	0.1
1992	307,950	0.1	484,300	0.1
1993	1,722,250	0.3	554,900	0.1
1994	391,700	0.1	187,800	0.1
1995	2,505,272	0.3	689,235	0.1
1996	317,252	0.02	235,195	0.02
Minimum	307,950	0.02	170,336	0.02
Average	881,299	0.16	378,042	0.09
Maximum	2,505,272	0.3	689,235	0.1

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Economically Infested Acreages (1988 - 1996) for Spider Mites on the Chlorfenapyr Label

Year	Spider Mites	# of Applications
1988	1,635,729	0.2
1989	1,599,112	0.2
1990	1,420,521	0.2
1991	769,633	0.1
1992	679,120	0.1
1993	902,255	0.1
1994	907,700	0.2
1995	1,392,789	0.1
1996	623,215	0.09
Minimum	623,215	0.09
Average	1,103,342	0.16
Maximum	1,635,729	0.2

Note: In cases where the # of applications rounded to 0.0 (1988 - 1995) in the published estimates, the value was increased to 0.1.

The budworm and bollworm complex reaches economically important levels on the largest number of acres year in and year out, and consistently requires the most treatments per acre. Recall that the chlorfenapyr labels allow at most 2 applications to the same field in any year. The other 3 pests infest smaller acreages and have far fewer of the economically infested acres treated.

CY190

Tests For the Difference Between Two Kaplan-Meier Curves With Investigations of Power

Prepared for:

Joseph P. Sullivan, Ph.D.
Ardea Consulting

Larry W. Brewer
Ecotoxicology & Biosystems Associates, Inc.

Prepared By:

John W. Kern

Western EcoSystems Technology Inc.
2003 Central Ave
Cheyenne, WY 82001

Statistical Methods

Data from marked birds were obtained from EBA Inc. personnel. The data consisted of time of mortality for birds from 2 reference and 2 treated sites. In the second treatment site there were no mortalities, so an initial analysis was conducted using only the first pair of reference / treated sites. An additional analysis was conducted comparing pooled reference to pooled treated sites. The analyses consisted of estimating Kaplan Meier survival probabilities with their corresponding standard errors at each of 7 equally spaced time periods (3, 6, 9, 12, 15, 18, and 21 days) measured in days since treatment. These survival estimates were then compared between treated and reference areas using an approximate Z statistic ($Z = (S_{treatment}-S_{reference})/SE(S_{treatment}-S_{reference})$). Because survival probabilities were at times higher on the treated sites than on the reference sites, a 2 tailed significance probability was reported in Tables 1 and 2 along with the lower 1-tailed test. The lower tailed test corresponds to the alternative that survival rates are lower in the treated area. The estimated survival probabilities, variances, Z statistics and significance probabilities are reported in Tables 1 and 2 for the individual and pooled comparisons respectively.

The power of these tests was simulated by investigating the power of tests obtained when the underlying survival times are assumed to come from a Weibull distribution (Bain 1978). The Weibull distribution is a flexible 2 parameter family for survival data which contains the exponential distribution as a special case. The parameters of the Weibull distribution were estimated from the Back of Fort reference study area using the method of maximum likelihood for right censored data (Bain 1978). Since the Z tests are sensitive to vertical differences in survival curves, the alternative distribution was specified by a vertical shift in survival curves at 2 specified times t=3 days and t=15 days. Given the parameters of the reference area, specification of a shift at 2 times allows one to solve for the Weibull parameters for the alternative distribution. The simulation was conducted for survival curves that were the same (the null hypothesis), and for cases where the survival probabilities were 10, 20, 30, 40, 50, 60, ...90% higher in the reference area than the treatment area. The power at each time period is given in Table (3) for the un-pooled one tailed tests and in Table (4) for the pooled one tailed tests. Simulated power for the 2 tailed tests is reported in Tables (5) and (6) for the un-pooled and pooled comparisons respectively. The significance levels for both the one and two tailed tests were chosen to be 0.05. Figure (1) shows the estimated survival curve under the assumption that survival times are from a right censored Wiebull distribution for the Back of Fort data. The pooled estimates of survival are plotted in Figure (2).

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Table 1. Kaplan-Meier estimates of survival probability for treated and reference areas including variance estimates and tests for differences in survival probability at times 3, 6, 9, 12, 15, 18 and 21 days after treatment

Time	Back of Fort Reference		Glenn Carroll Treated			2-tailed	Lower-tailed
(days)	Survival	Variance	Survival	Variance	Z	Prob	Prob
3	1.0	0.0	0.9167	0.0058	-1.09	0.28	0.14
6	1.0	0.0	0.8333	0.0105	-1.62	0.10	0.05
9	0.857	0.0150	0.8333	0.0116	-0.15	0.88	0.44
12	0.857	0.0175	0.5833	0.0142	-1.54	0.12	0.06
15	0.857	0.0175	0.5833	0.0203	-1.4	0.15	0.08
18	0.571	0.0233	0.5833	0.0203	0.06	0.95	0.53
21	0.571	0.0350	0.5833	0.0203	0.05	0.96	0.52

Table 2. Kaplan-Meier estimates of survival probability for pooled treated and reference areas including variance estimates and tests for differences in survival probability at times 3, 6, 9, 12, 15, 18 and 21 days after treatment

Time	Pooled Reference		Pooled Treated			2-tailed	Lower-tailed
days	Survival	Variance	Survival	Variance	Z	Prob	Prob
3	0.8889	0.0049	0.9630	0.0013	0.94	0.34	0.83
6	0.8889	0.0059	0.9259	0.0024	0.41	0.68	0.66
9	0.8254	0.0085	0.9259	0.0025	0.96	0.34	0.83
12	0.8254	0.0092	0.8148	0.0049	-0.09	0.93	0.47
15	0.8254	0.0092	0.8148	0.0059	-0.09	0.93	0.47
18	0.6003	0.0131	0.8148	0.0059	1.56	0.12	0.94
21	0.6003	0.0180	0.7760	0.0064	1.12	0.26	0.87

Table 3. Simulated power of approximate Z tests with 5% one tailed significance level for each time period under the assumption that survival times are from a 2 parameter Weibull distribution. The sample sizes those observed in the Back of Fort reference area (n=7) and the Glen Carroll treated site (n=12).

	Ratio of Reference Survival to Treatment Survival									
Time	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
3.00	0.00	0.30	0.62	0.78	0.90	0.96	0.97	0.99	0.99	0.99
6.00	0.00	0.29	0.56	0.69	0.82	0.89	0.92	0.96	0.97	0.98
9.00	0.02	0.37	0.59	0.70	0.79	0.86	0.88	0.91	0.93	0.95
12.00	0.10	0.33	0.49	0.54	0.66	0.72	0.74	0.79	0.81	0.86
15.00	0.14	0.16	0.26	0.31	0.40	0.43	0.49	0.55	0.58	0.62
18.00	0.08	0.05	0.07	0.09	0.13	0.16	0.19	0.21	0.23	0.30
21.00	0.10	0.00	0.01	0.02	0.02	0.02	0.03	0.04	0.04	0.05

Table 4. Simulated power of approximate Z tests with 5% one tailed significance level for each time period under the assumption that survival times are from a 2 parameter Weibull distribution. The sample sizes were those observed in the pooled reference (n=18) and treated (n=27) sites.

	Ratio of Reference Survival to Treatment Survival									
Time	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
3.00	0.00	0.42	0.83	0.95	0.99	1.00	1.00	1.00	1.00	1.00
6.00	0.00	0.74	0.94	0.98	1.00	1.00	1.00	1.00	1.00	1.00
9.00	0.01	0.76	0.91	0.96	0.98	0.99	1.00	1.00	1.00	1.00
12.00	0.10	0.60	0.76	0.85	0.92	0.95	0.97	0.98	0.99	0.99
15.00	0.15	0.28	0.42	0.55	0.68	0.76	0.83	0.88	0.90	0.93
18.00	0.15	0.05	0.10	0.17	0.26	0.32	0.39	0.46	0.51	0.56
21.00	0.19	0.00	0.00	0.01	0.02	0.04	0.05	0.07	0.10	0.13

Table 5. Simulated power of approximate Z tests with 5% two tailed significance level for each time period under the assumption that survival times are from a 2 parameter Weibull distribution. The sample sizes those observed in the Back of Fort reference area (n=7) and the Glen Carroll treated site (n=12).

	Ratio of Reference Survival to Treatment Survival									
Time	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
3.00	0.00	0.10	0.31	0.58	0.73	0.84	0.88	0.93	0.95	0.97
6.00	0.00	0.26	0.53	0.72	0.82	0.89	0.93	0.94	0.96	0.98
9.00	0.01	0.38	0.58	0.71	0.80	0.84	0.87	0.88	0.89	0.93
12.00	0.07	0.37	0.45	0.56	0.60	0.64	0.68	0.72	0.73	0.76
15.00	0.14	0.20	0.23	0.27	0.31	0.32	0.39	0.43	0.45	0.48
18.00	0.15	0.15	0.11	0.12	0.14	0.13	0.17	0.16	0.17	0.22
21.00	0.16	0.39	0.32	0.27	0.24	0.20	0.17	0.14	0.15	0.14

Table 6. Simulated power of approximate Z tests with 5% two tailed significance level for each time period under the assumption that survival times are from a 2 parameter Weibull distribution. The sample sizes were those observed in the pooled reference (n=18) and treated (n=27) sites.

	Ratio of Reference Survival to Treatment Survival									
Time	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
3.00	0.00	0.20	0.65	0.89	0.96	0.99	1.00	1.00	1.00	1.00
6.00	0.00	0.51	0.85	0.95	0.98	0.99	1.00	1.00	1.00	1.00
9.00	0.00	0.61	0.84	0.92	0.97	0.99	0.99	1.00	0.99	1.00
12.00	0.06	0.44	0.68	0.78	0.87	0.91	0.93	0.95	0.96	0.99
15.00	0.08	0.17	0.33	0.42	0.57	0.66	0.73	0.80	0.83	0.87
18.00	0.11	0.09	0.09	0.11	0.17	0.24	0.28	0.35	0.40	0.46
21.00	0.14	0.34	0.24	0.17	0.11	0.09	0.08	0.07	0.07	0.10

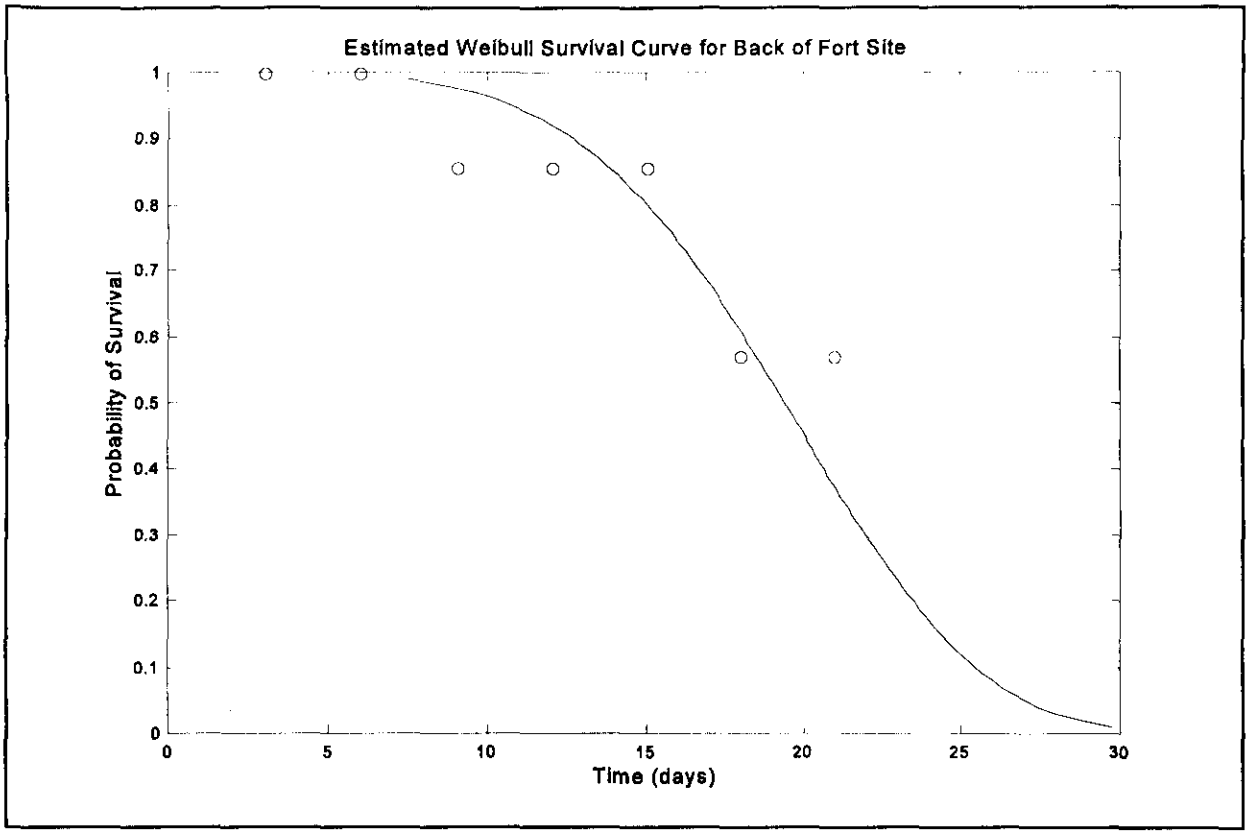

Figure 1. Estimated Weibull survival function for reference area survival data. The parameters were estimated by maximum likelihood for right censored data (Bain, 1978). The estimated parameters are $\theta = 21.0851$ and $\beta = 4.43$.

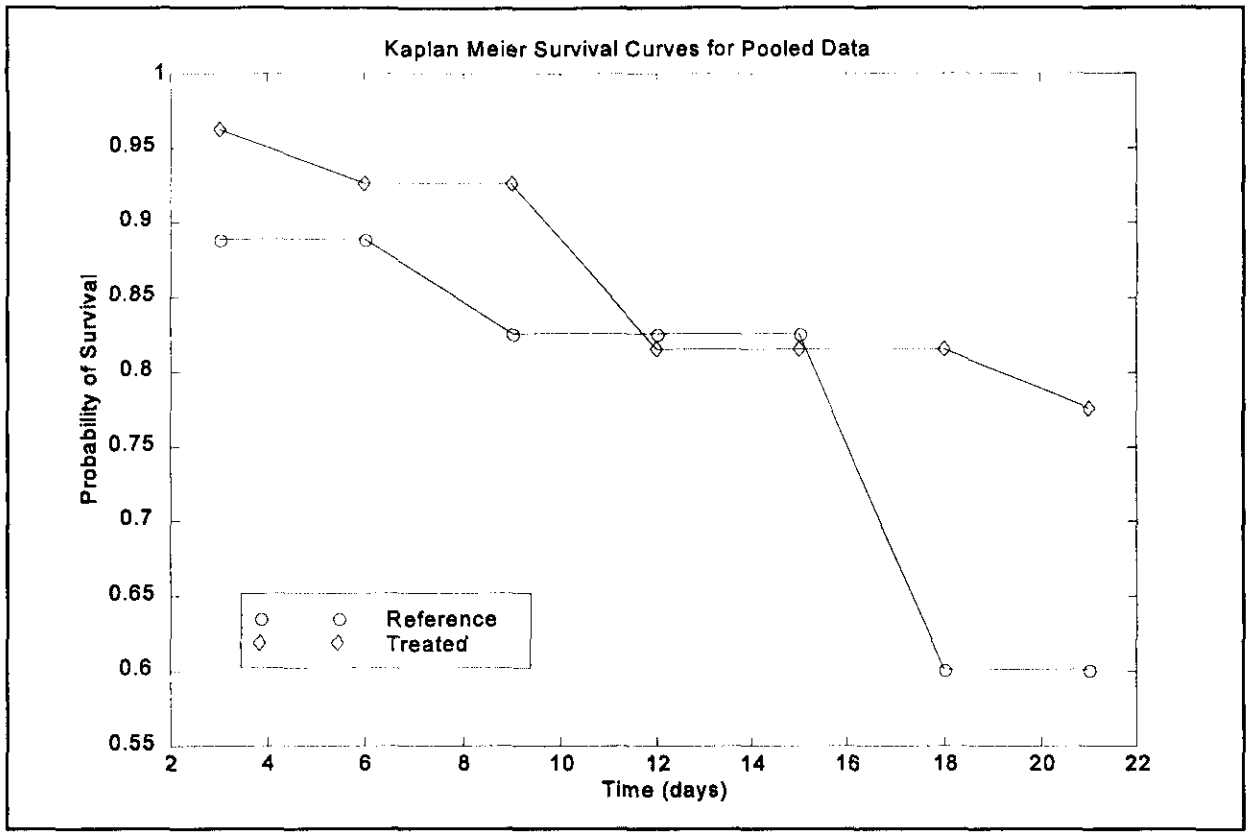

Figure 2. Kaplan-Meier survival curves for pooled reference and treated sites.

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