Development of International Risk-Based Phytosanitary Performance Standards

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Phytosanitary Performance Standards

- Defined as a probabilistic tolerance.
- Monte Carlo techniques used to generate a response surface relating proportional pest survival to treatment time and temperature.
- Modeling approach avoids parametric assumptions of conventional methods.
- Estimate series of time-temperature combos that are equivalent in terms of performance.

Data

- Newbill and Morrell (1991)
  - Heat Treatment
  - Thermotolerant decay fungi (*Postia placenta* and *Antrodia carbonica*)
  - Douglas-fir

Table 1. Survival at elevated temperatures of *Postia placenta* in Douglas-fir

Exposure	Temp (C)								
(hr)	48.9	51.7	54.4	57.2	60	62.8	65.6	68.4	71.1
0.25	1.00	1.00	1.00	0.96	0.92	0.83	0.33	0.25	0.67
0.5	1.00	1.00	0.96	0.92	1.00	0.92	0.08	0.25	0.00
1	1.00	1.00	1.00	1.00	0.75	0.67	0.08	0.00	0.00
1.25	1.00	0.96	1.00	0.96	0.67	0.33	0.00	0.00	0.00
1.5	1.00	0.96	0.96	0.92	0.58	0.42	0.00	0.00	0.00
2	1.00	1.00	1.00	0.92	0.25	0.00	0.00	0.00	0.00
3	1.00	0.92	0.83	0.75	0.33	0.00	0.00	0.00	0.00
4	1.00	1.00	0.92	0.58	0.25	0.00	0.00	0.00	0.00
6	0.92	1.00	0.83	0.17	0.00	0.00	0.00	0.00	0.00
12	1.00	0.92	0.33	0.00	0.00	0.00	0.00	0.00	0.00
15	0.92	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.83	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.17	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Figure 1. Reported Data for Survival of *P. placenta* in Douglas-fir at Elevated Temperatures

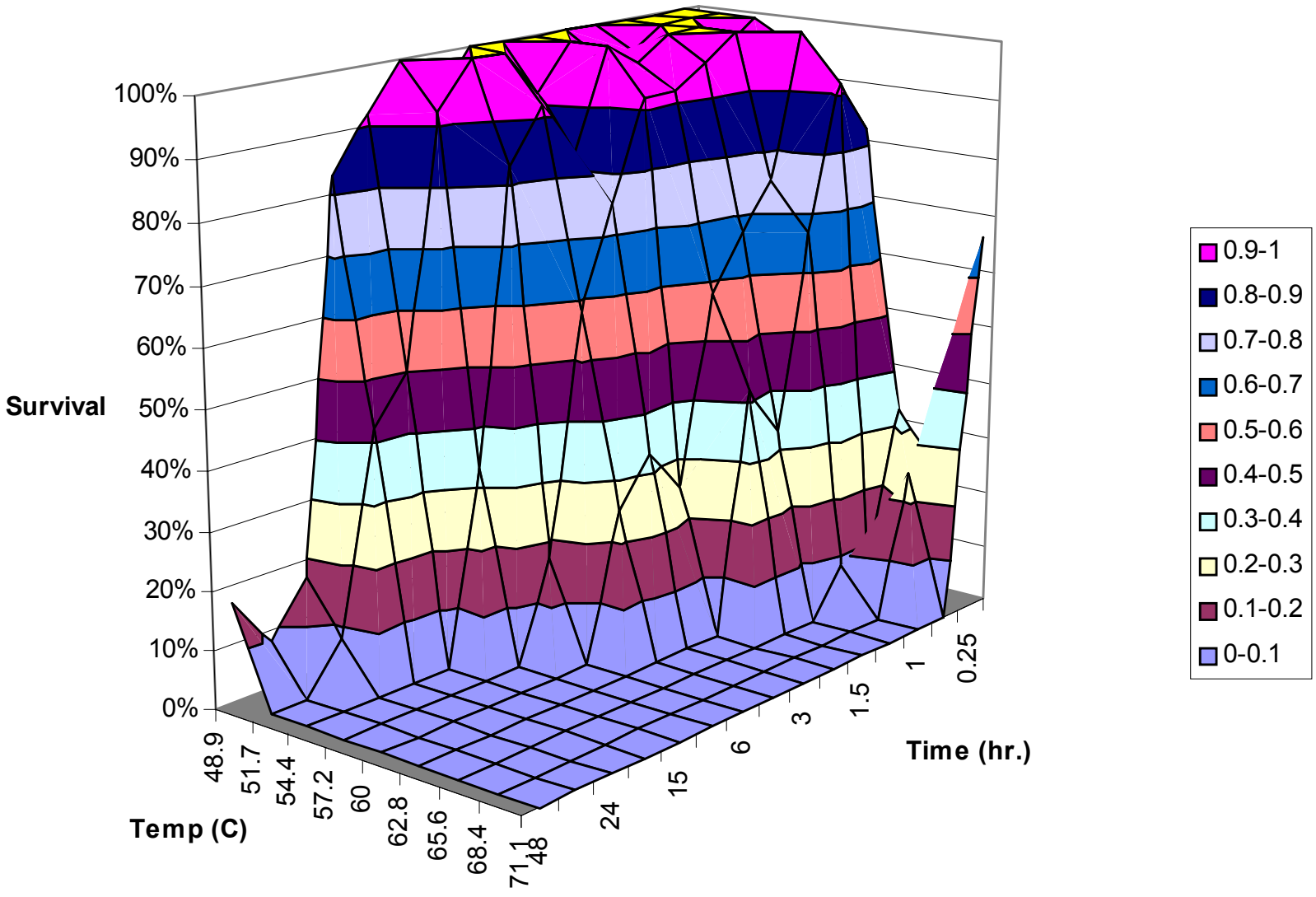
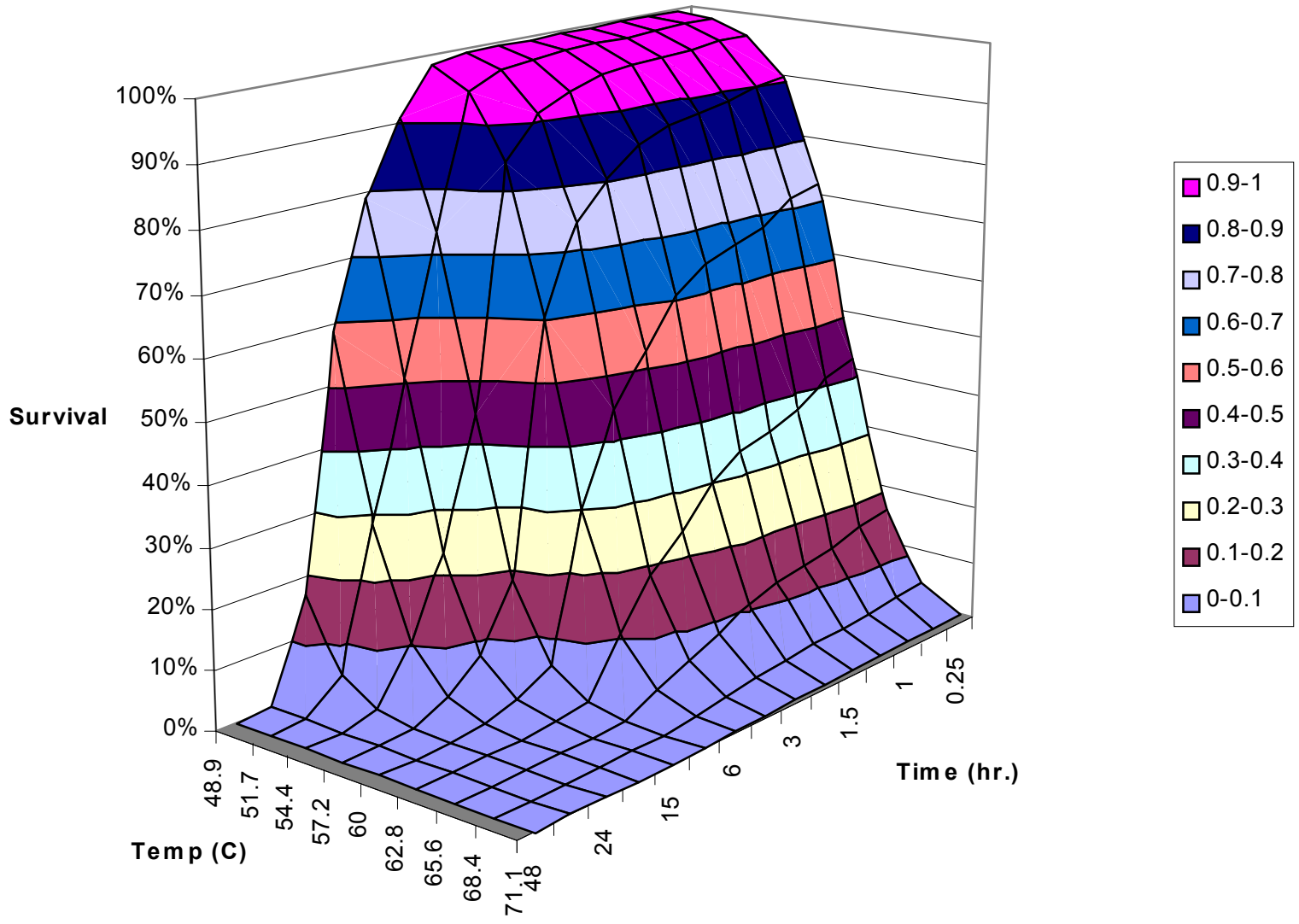


Figure 2. Logistic Response Surface for Survival of *P. placenta* in Douglas-fir at Elevated Temperatures



Alternative Response Surface Modeling Approach

- Proportion (survival) ~ Beta
- Subject to the biological constraint that plant pest survival should decrease monotonically with increased time and temperature

Table 2. Survival at elevated temperatures of *Postia placenta* in Douglas-fir

Exposure	Temp (C)								
(hr)	48.9	51.7	54.4	57.2	60	62.8	65.6	68.4	71.1
0.25	48	48	48	46	44	40	16	12	32
0.5	48	48	46	44	48	44	4	12	0
1	48	48	48	48	36	32	4	0	0
1.25	48	46	48	46	32	16	0	0	0
1.5	48	46	46	44	28	20	0	0	0
2	48	48	48	44	12	0	0	0	0
3	48	44	40	36	16	0	0	0	0
4	48	48	44	28	12	0	0	0	0
6	44	48	40	8	0	0	0	0	0
12	48	44	16	0	0	0	0	0	0
15	44	24	0	0	0	0	0	0	0
18	40	20	0	0	0	0	0	0	0
24	8	4	0	0	0	0	0	0	0
36	4	0	0	0	0	0	0	0	0
48	8	0	0	0	0	0	0	0	0

Proportion (survival|$time_i$, $temp_j$) ~
MIN(Prop.(survival|$time_{i-1}$, $temp_j$), Prop.(survival|$time_i$, $temp_{j-1}$),
Beta(s_{ij}+1, n_{ij}-s_{ij}+1)) (s_{ij} = cell value; n_{ij}=48)

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2	48	48	48	44	12	0	0	0	0
3	48	44	40	36	16		0	0	0
4	48	48	44	28	beta(13, 37)	0	0	0	0
6	44	48	40		0	0	0	0	0
12	48	44	16		0	0	0	0	0
15	44	24	0		0	0	0	0	0
18	40	20	0	0	0	0	0	0	0
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2	48	48	48	44	12	0	0	0	0
3	48	44	40	36	beta(17,33)		0	0	0
4	48	48	44	beta(29,21)	beta(13, 37)	0	0	0	0
6	44	48	40		0	0	0	0	0
12	48	44	16		0	0	0	0	0
15	44	24	0		0	0	0	0	0
18	40	20	0	0	0	0	0	0	0
24	8	4	0	0	0	0	0	0	0
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Proportion (survival|time$_i$, temp$_j$) ~
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Figure 3. Mean Beta Model Response Surface for Survival of *P. placenta* in Douglas-fir at Elevated Temperatures

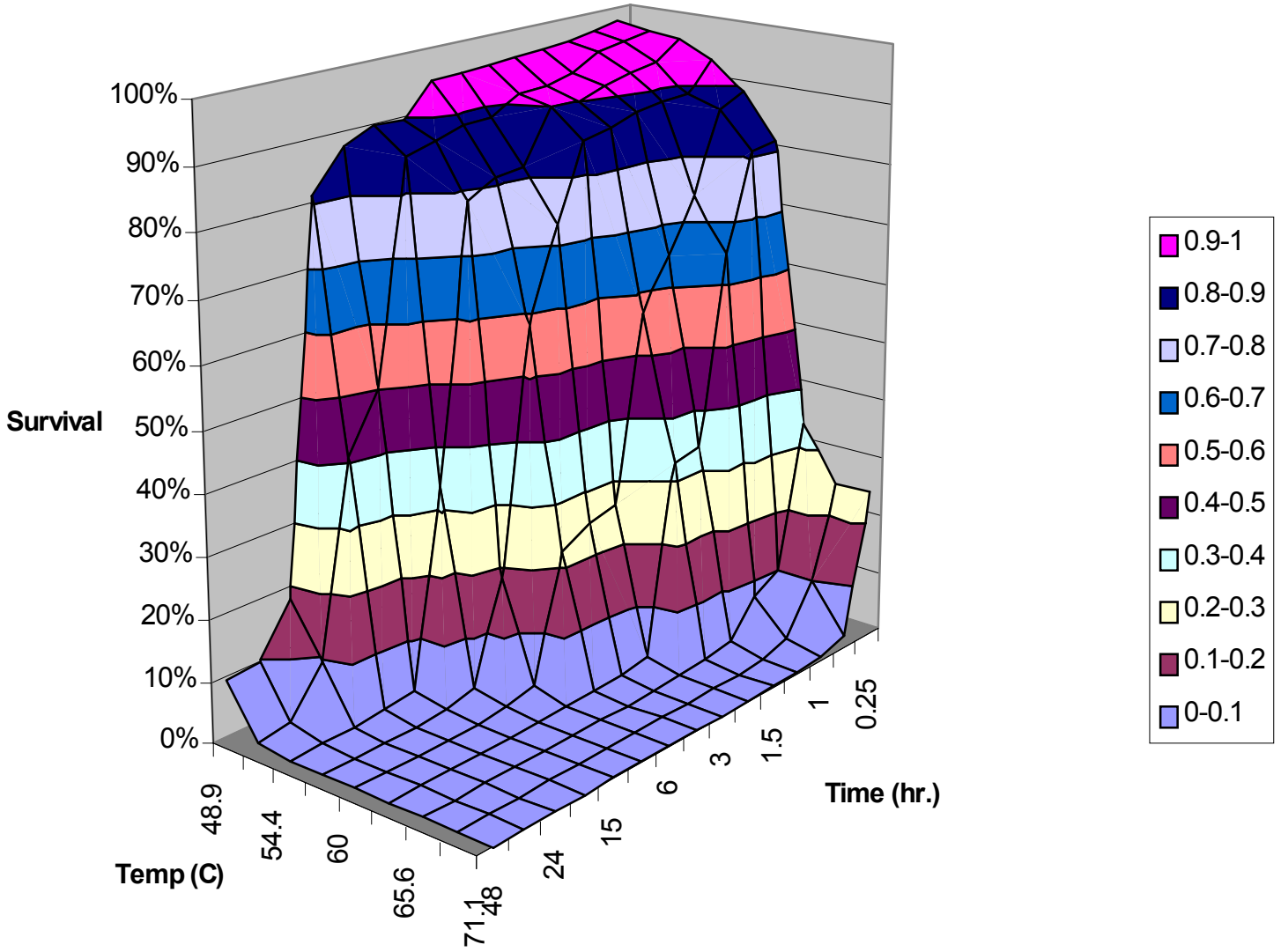
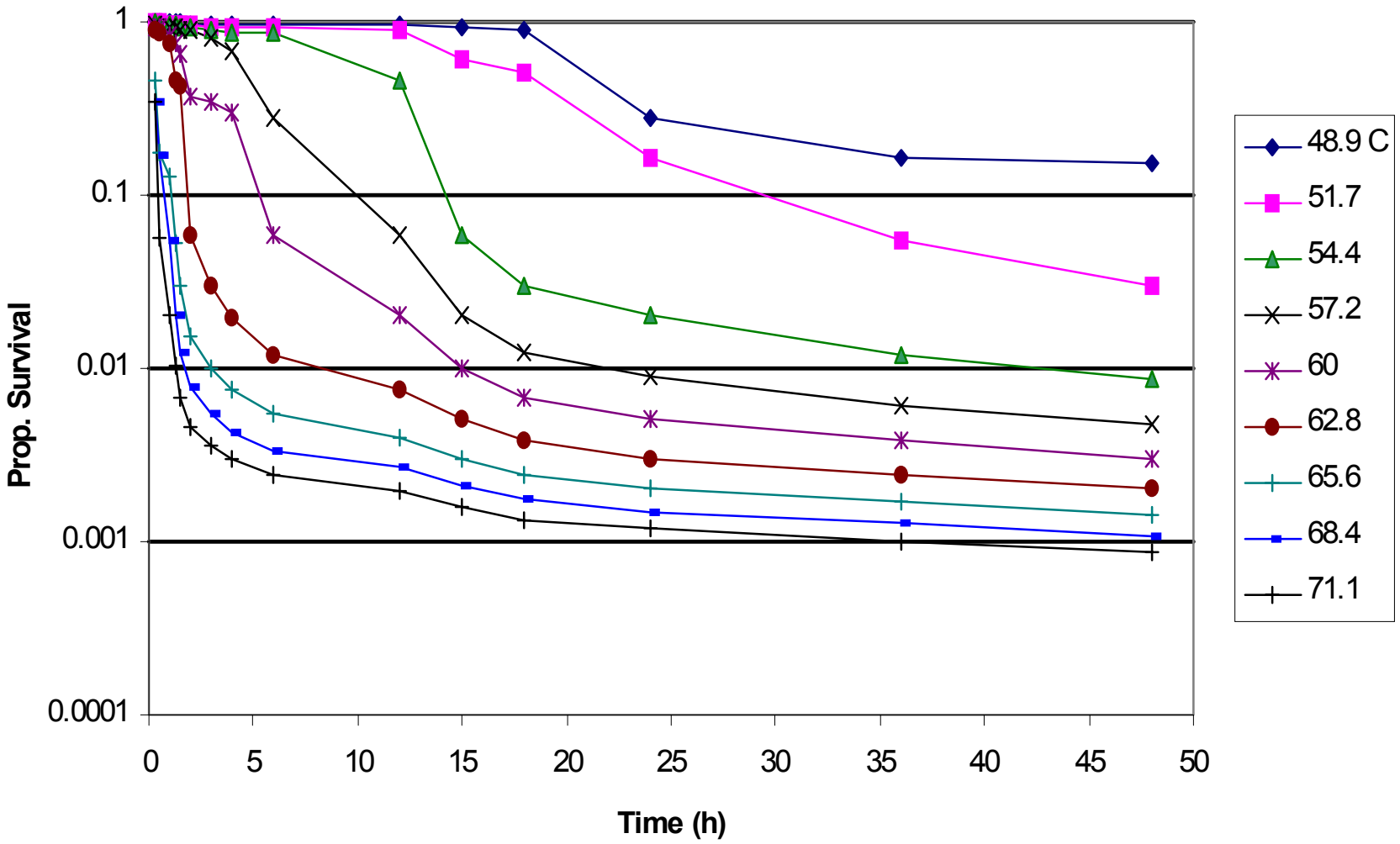


Figure 4. 95th Percentile Survival Curves for for *P. placenta* in Douglas-fir



Generate Iso-Safety Curves

- Estimate the time required at each temperature to provide 95% confidence that the lethality achieved is at least 90 and 99 percent

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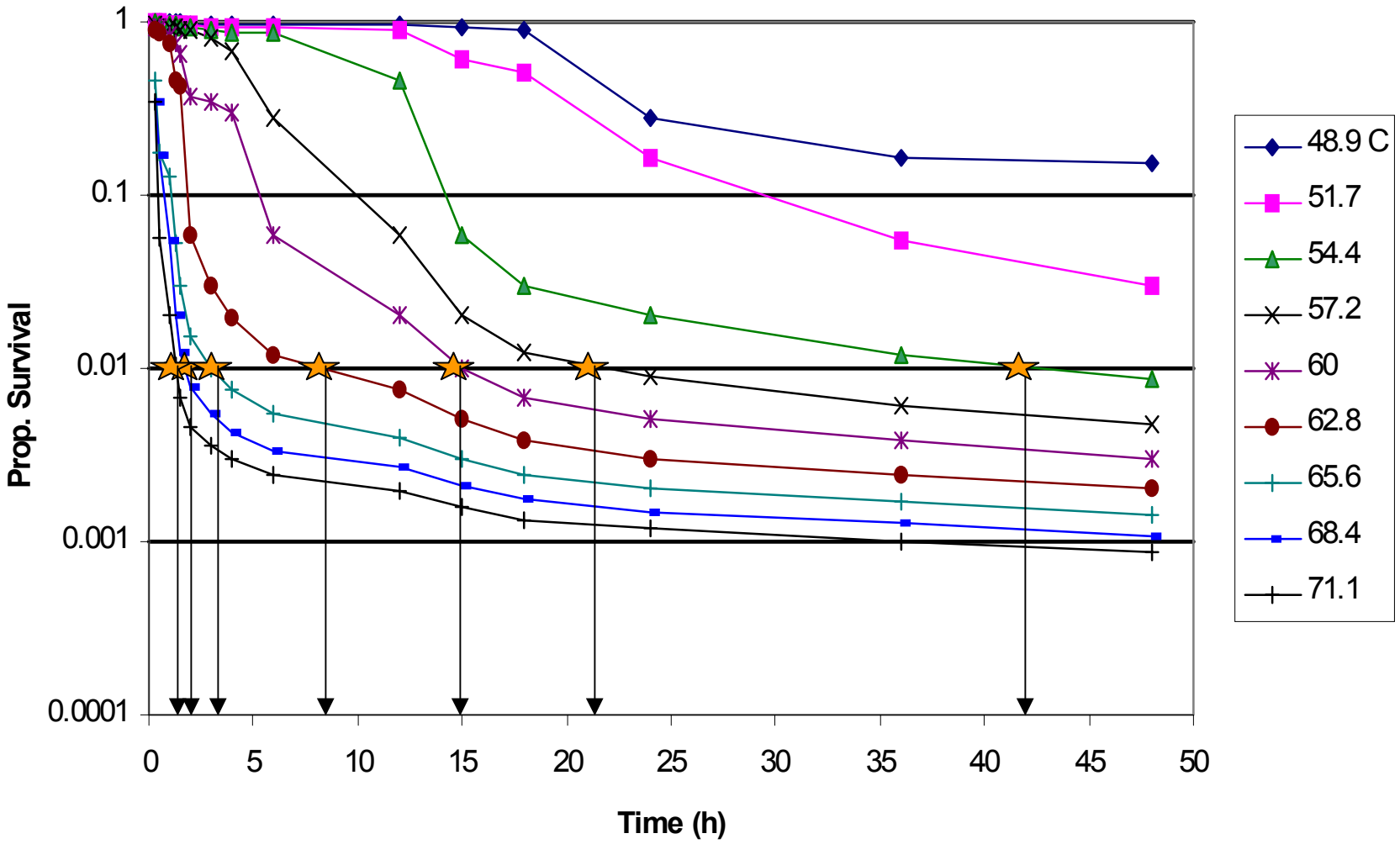
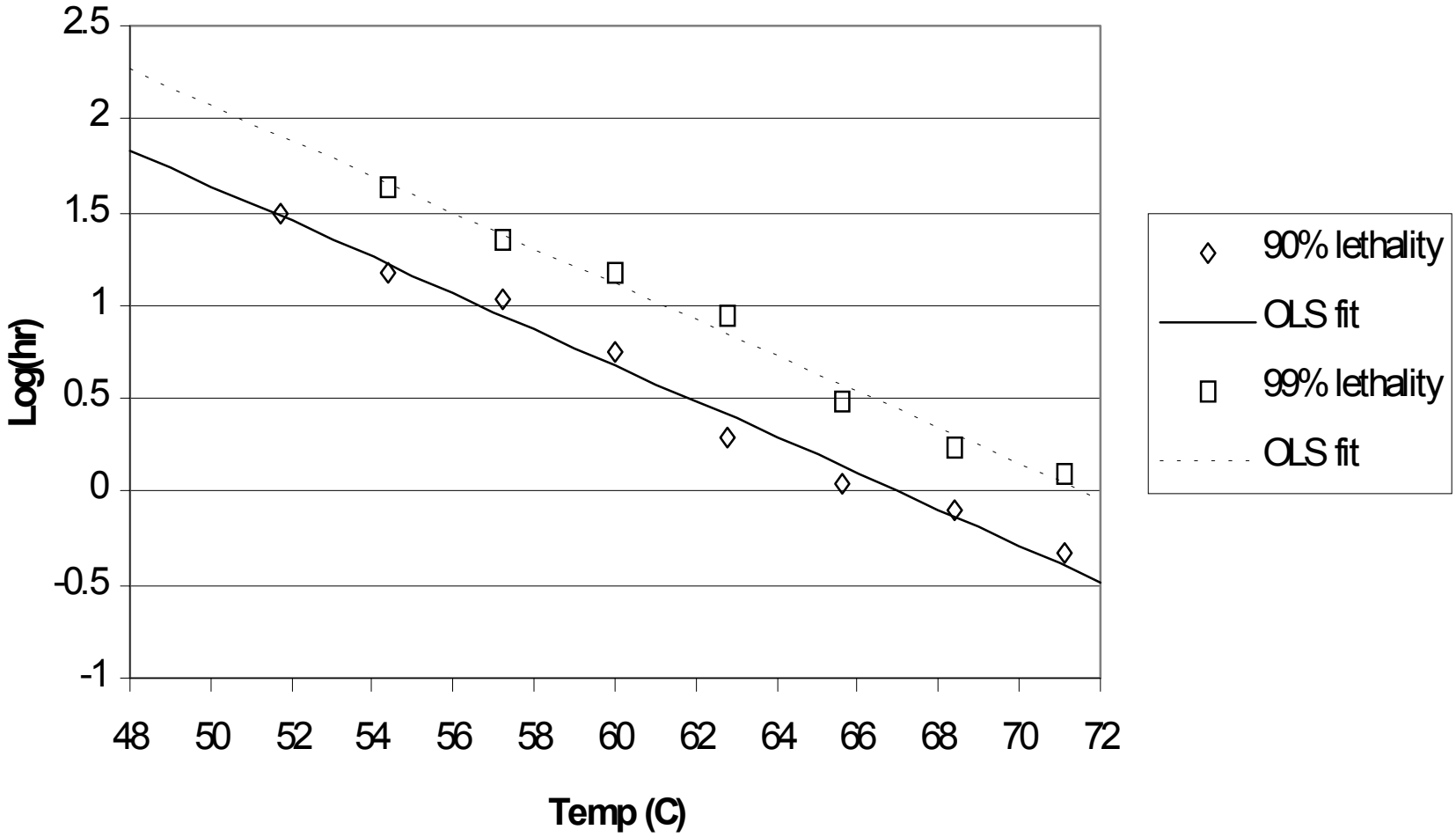


Generate Iso-Safety Curves

- Estimate the time required at each temperature to provide 95% confidence that the lethality achieved is at least 90 and 99 percent.
- Log(Time (h)) =

$$b_0 + b_1 * (\text{Temperature } (^\circ \text{C}))$$

Figure 5. 95th Percentile Iso-Safety Curves for *P. placenta* in Douglas-fir



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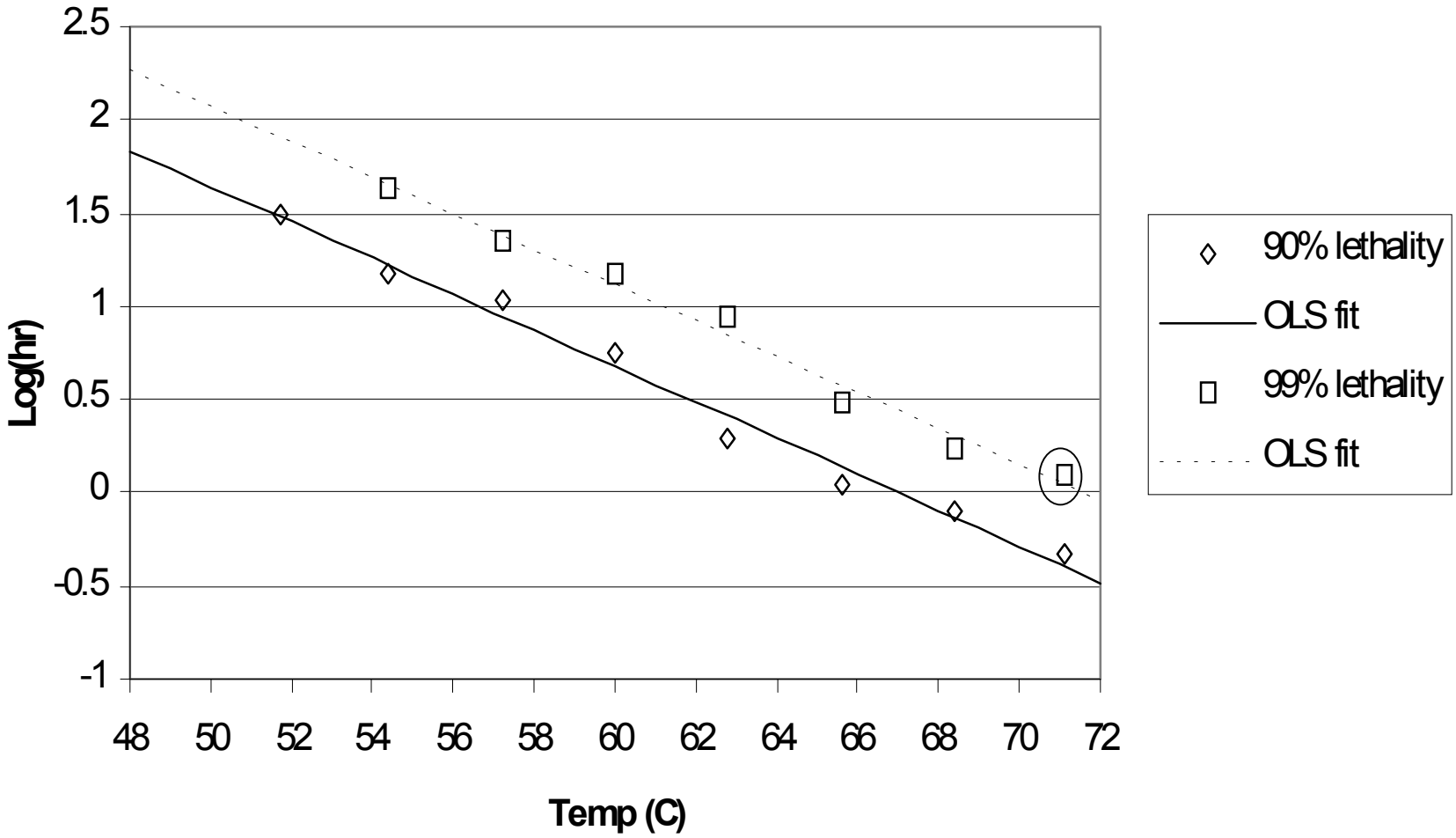

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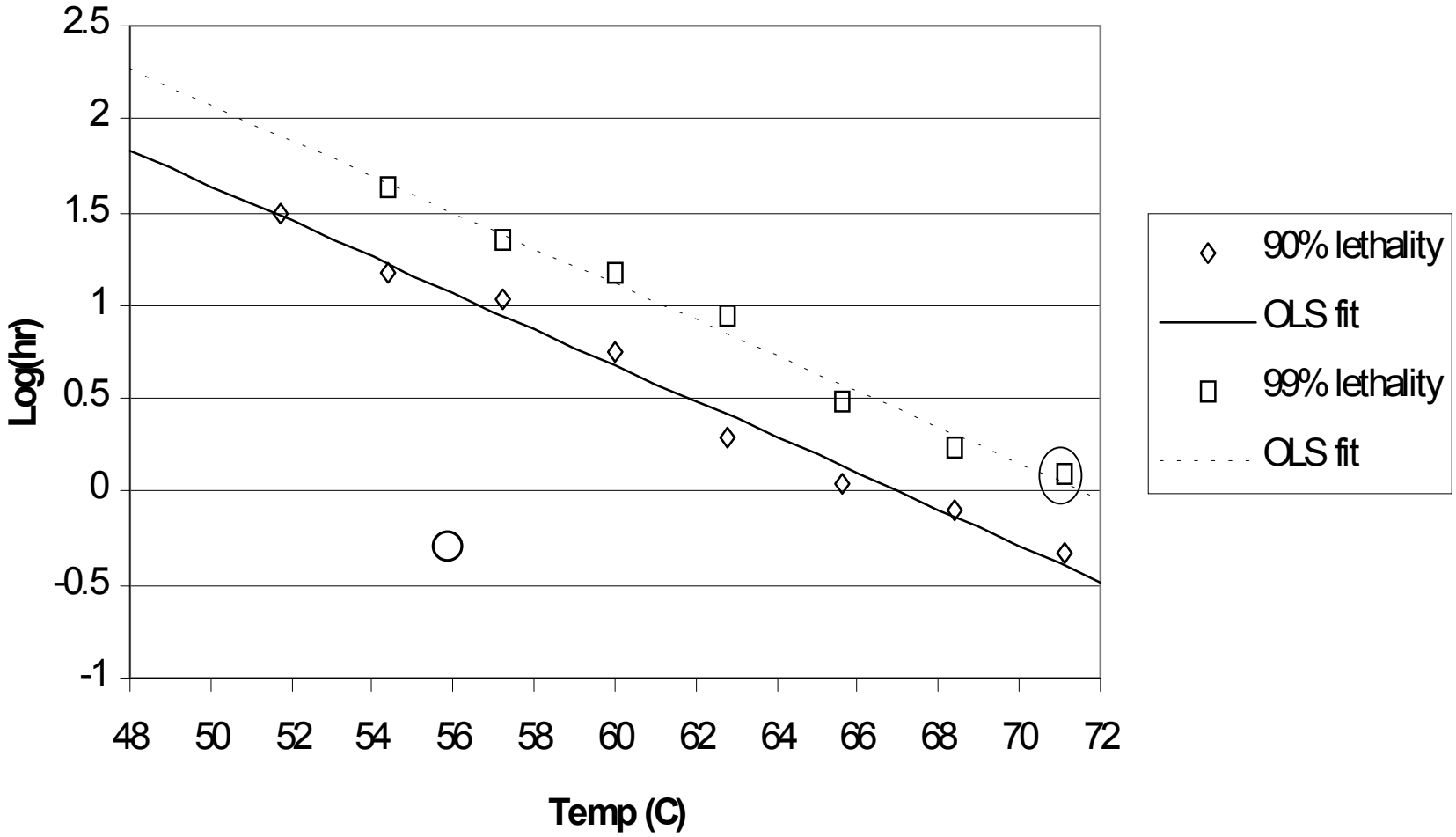

Phytosanitary Performance Standards

- Link risk mitigation measures to an explicit tolerance
- Provide flexibility in achieving the desired level of protection
- Enable determination of the equivalence of alternative measures