APPENDIX A

Figures of injury data from the spring fog and summer ozone exposure studies.

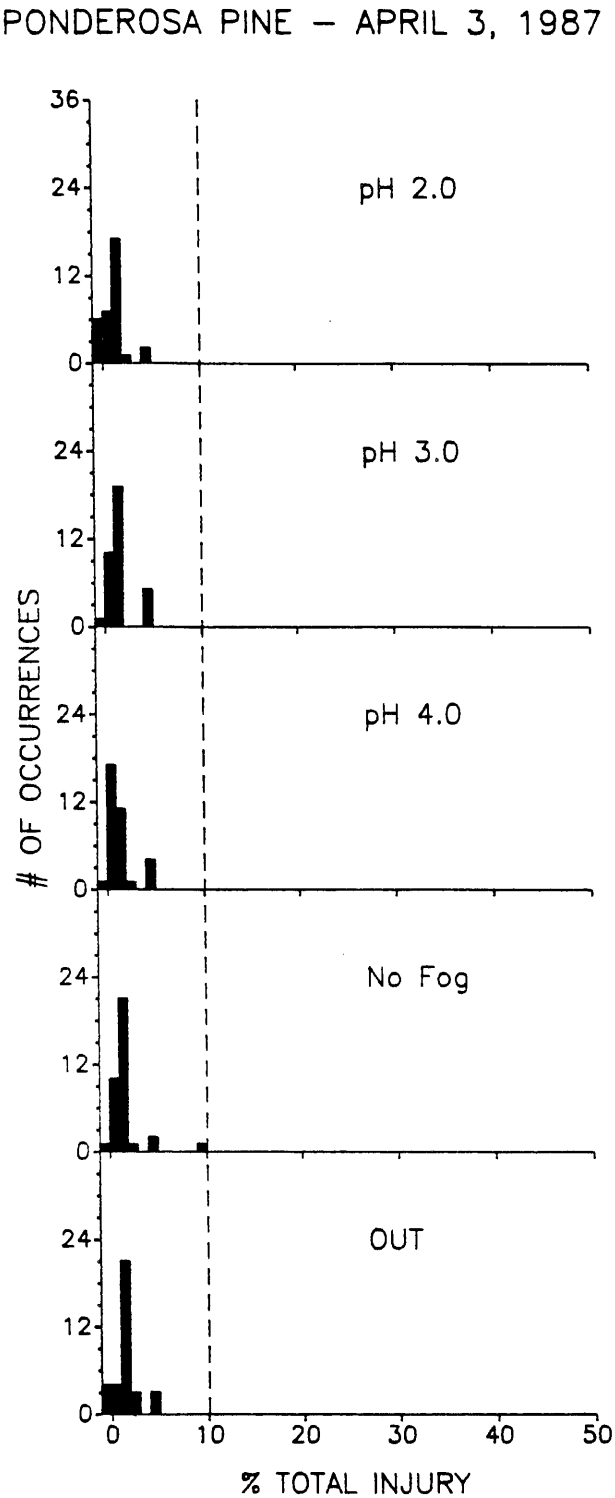

Figure A-1. Effects of fog chemistry on distribution of injury amounts to 1986 needles of ponderosa pine on April 3, 1987. The broken vertical line at 10% total foliar injury was arbitrarily selected, and separates trees considered severely injured (>10% total injury) from less injured trees.

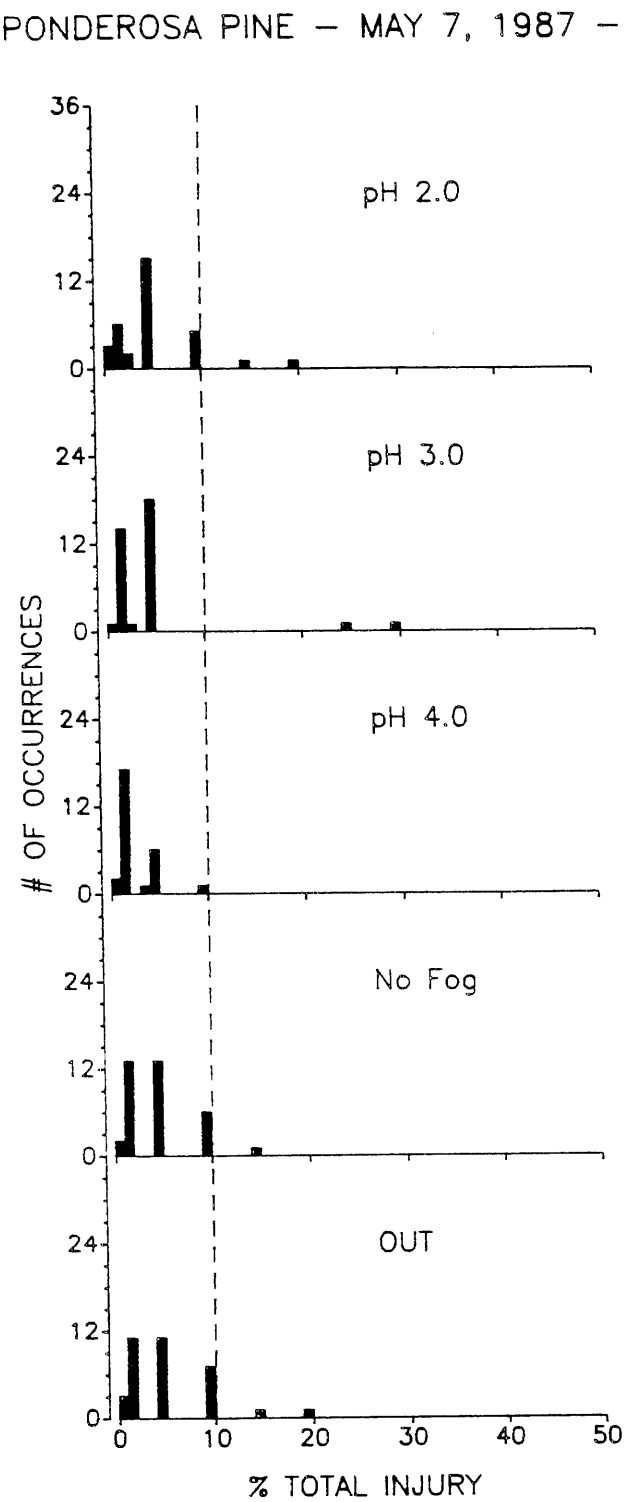

Figure A-2. Effects of fog chemistry on distribution of injury amounts to 1986 needles of ponderosa pine on May 7, 1987 (see Figure A-1 for explanation).

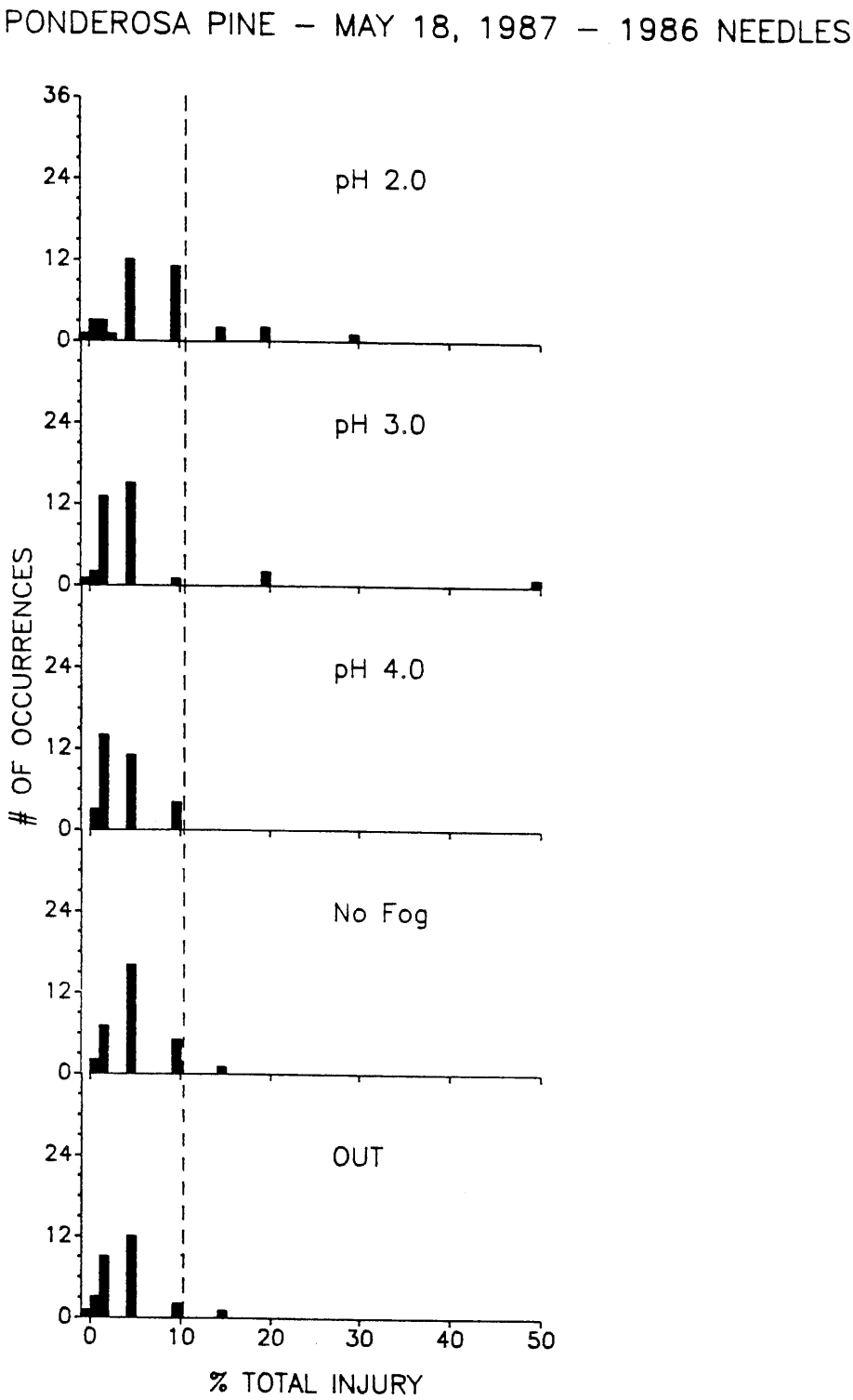

Figure A-3. Effects of fog chemistry on distribution of injury amounts to 1986 needles of ponderosa pine on May 18, 1987 (see Figure A-1 for explanation).

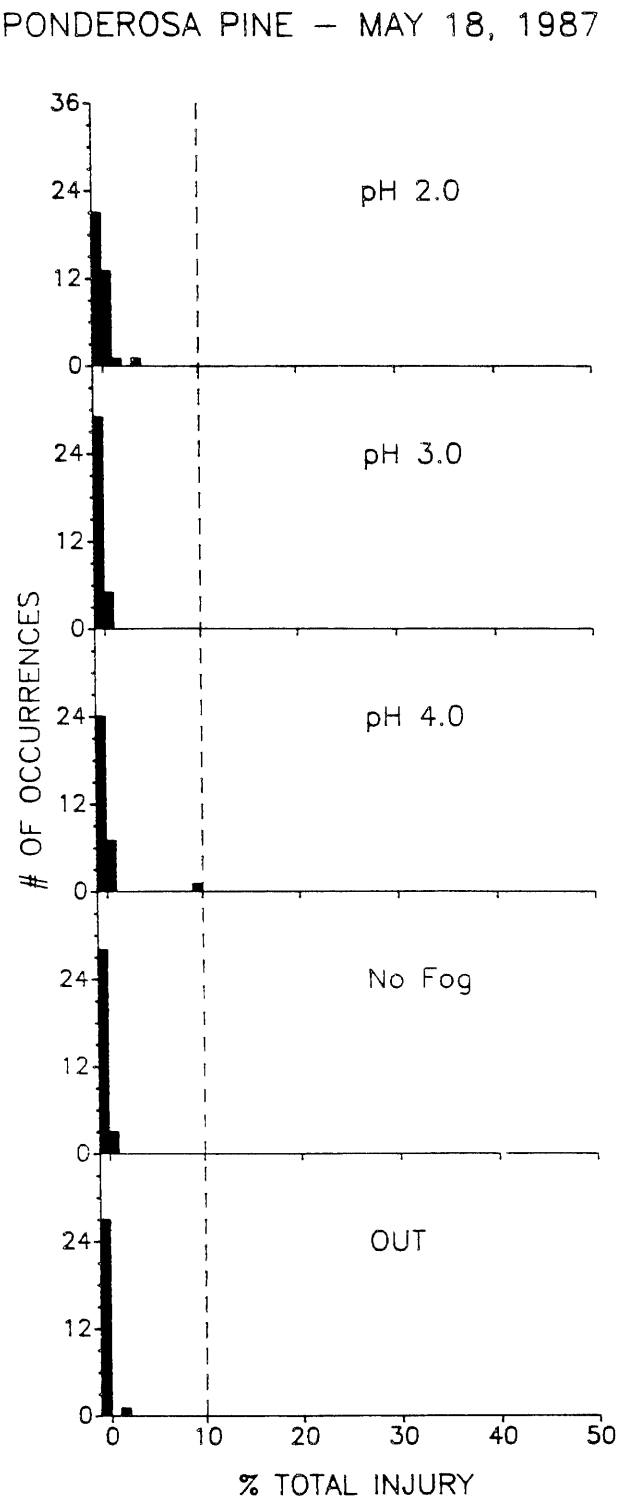

Figure A-4. Effects of fog chemistry on distribution of injury amounts to 1987 needles of pondersa pine on May 18, 1987 (see Figure A-1 for explanation).

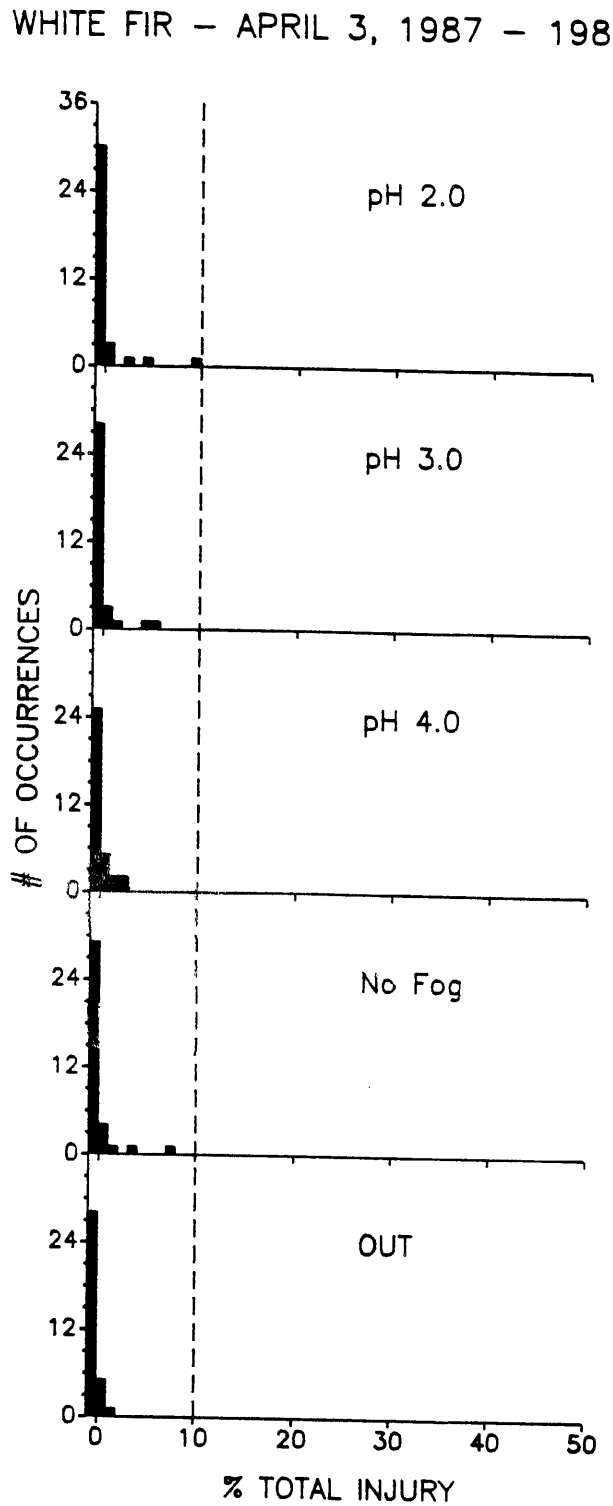

Figure A-5. Effects of fog chemistry on distribution of injury amounts to 1986 needles of white fir on April 3, 1987 (see Figure A-1 for explanation).

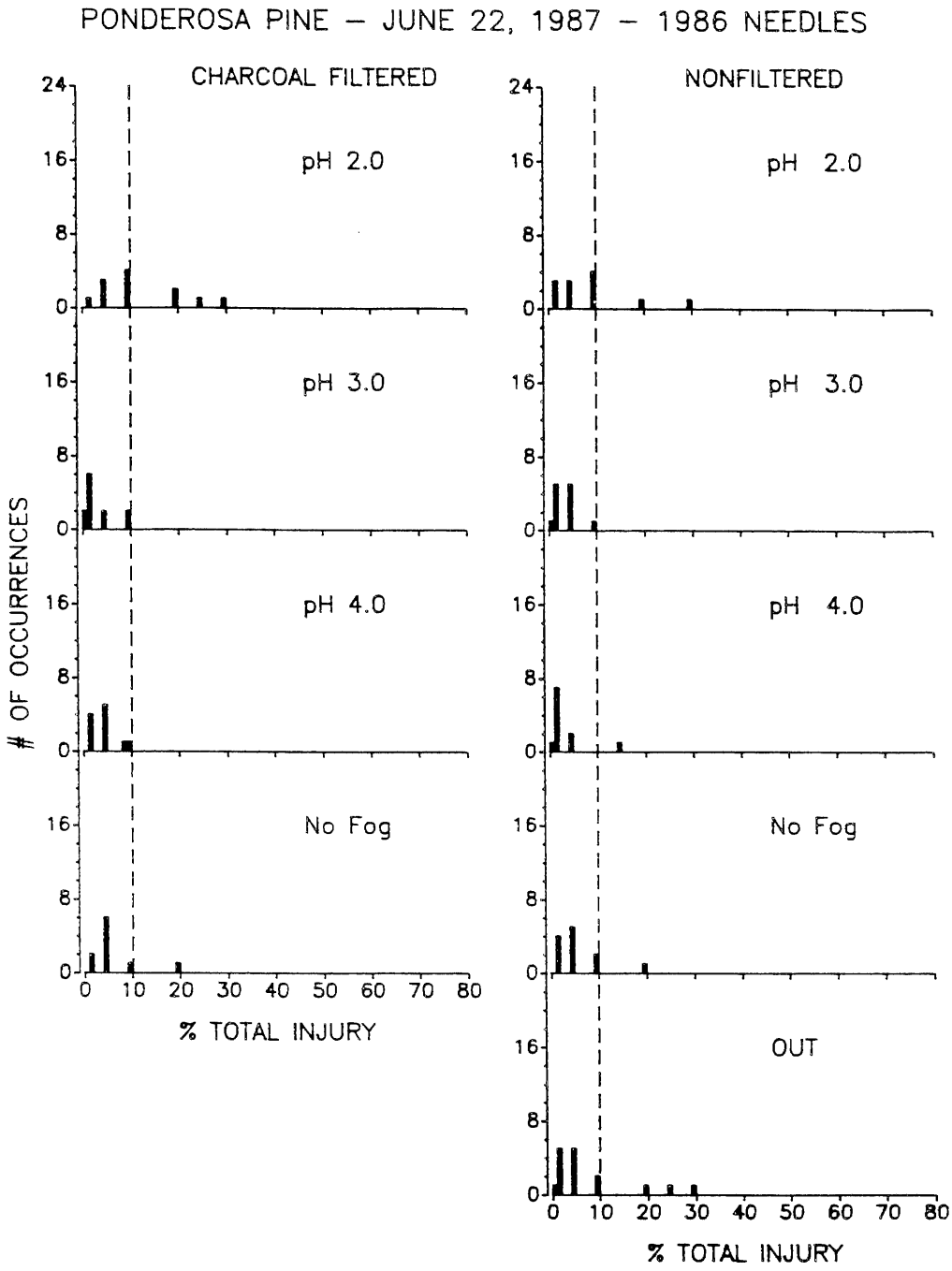

Figure A-6. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1986 needles of ponderosa pine on June 22, 1987 (see Figure A-1 for explanation).

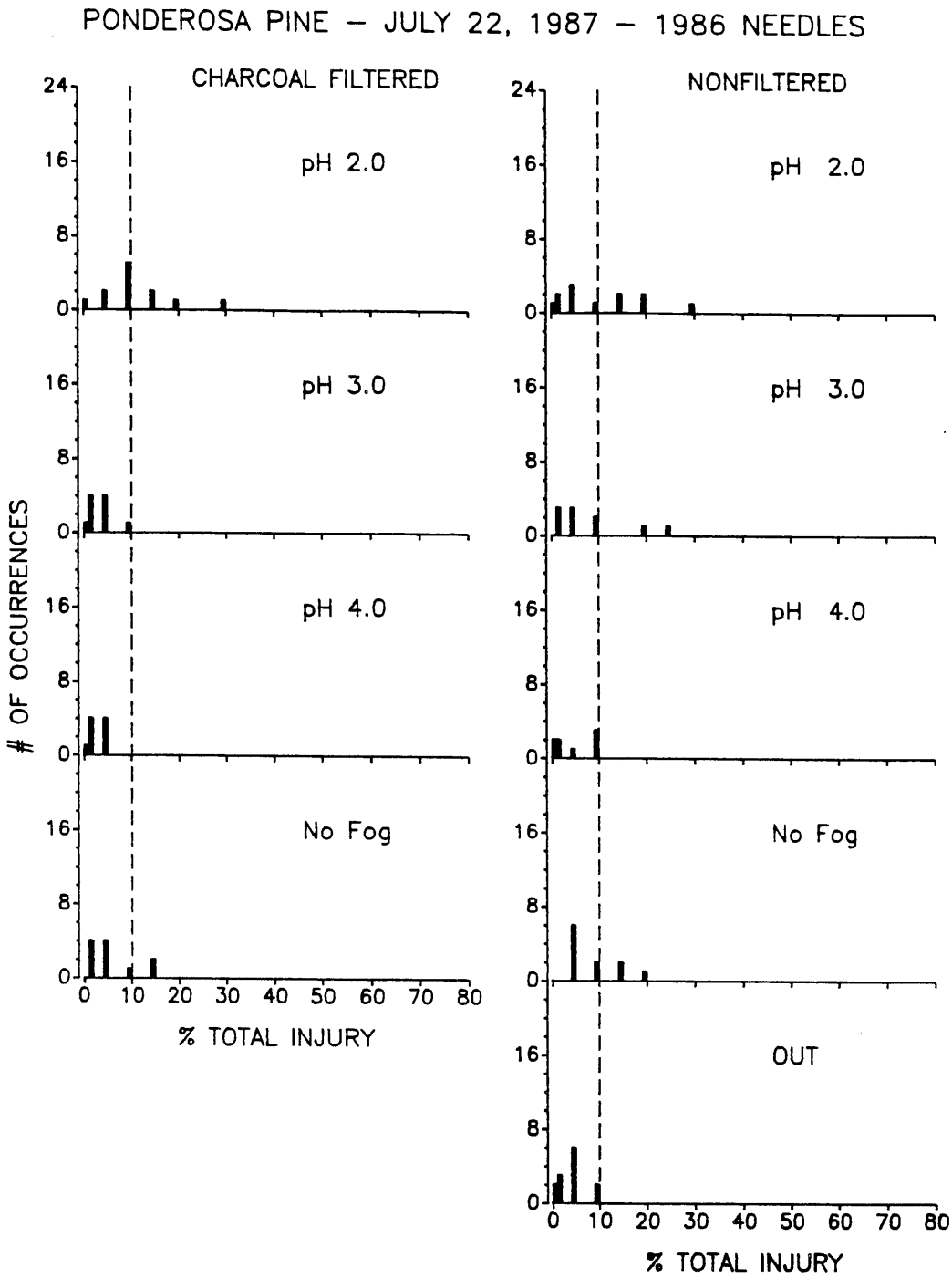

Figure A-7. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1986 needles of ponderosa pine on July 22, 1987 (see Figure A-1 for explanation).

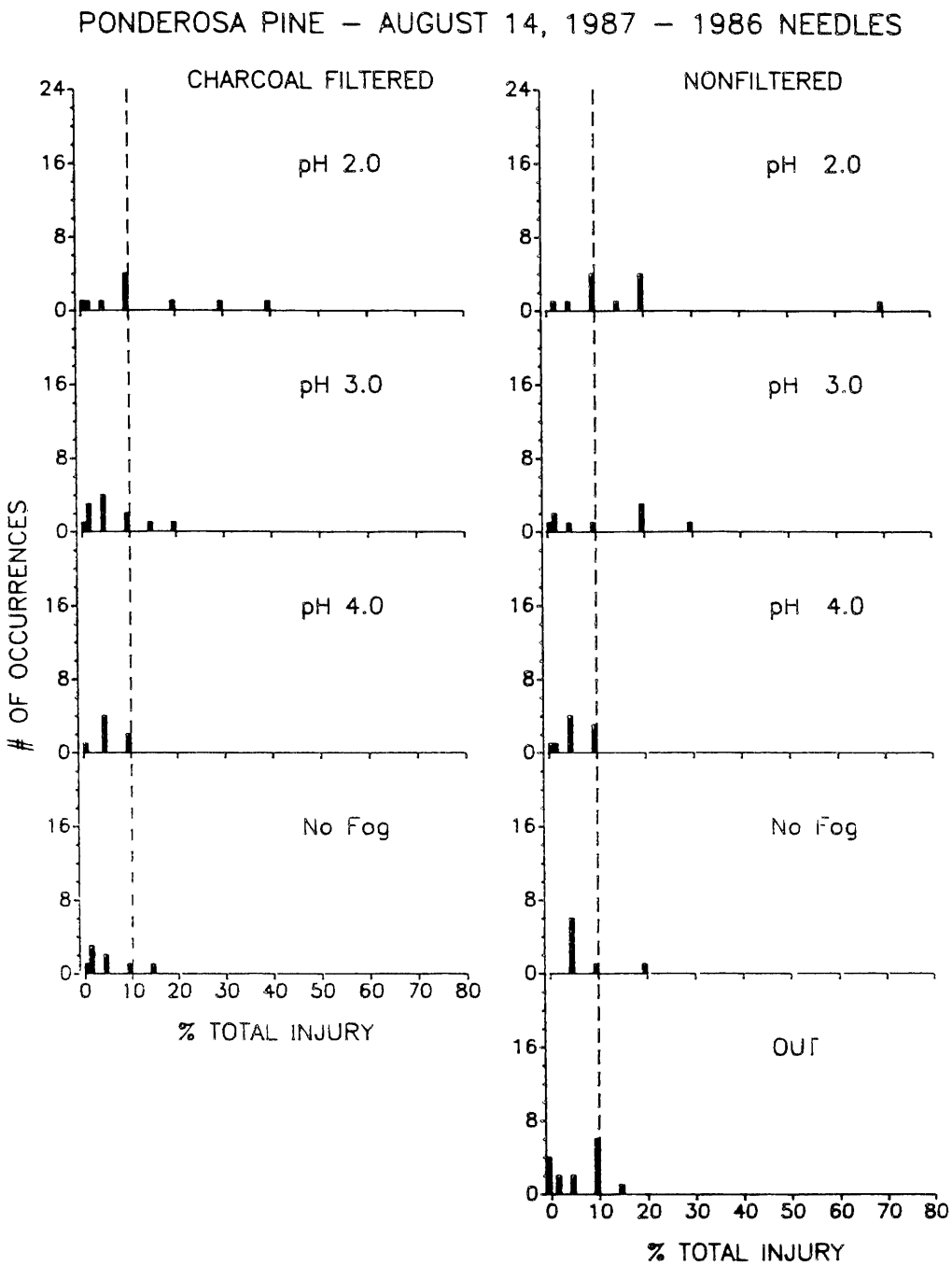

Figure A-8. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1986 needles of ponderosa pine on August 14, 1987 (see Figure A-1 for explanation).

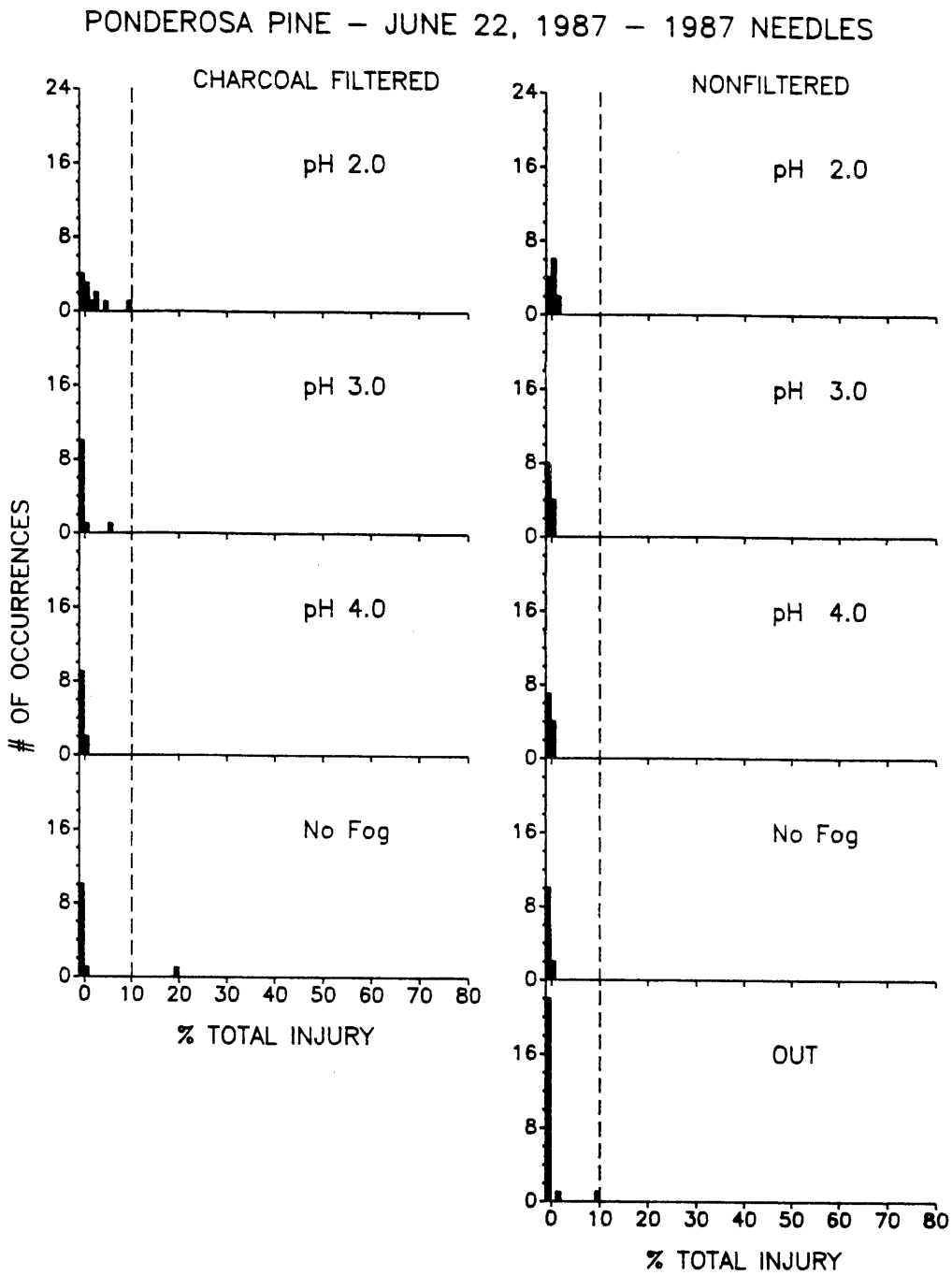

Figure A-9. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1987 needles of ponderosa pine on June 22, 1987 (see Figure A-1 for explanation).

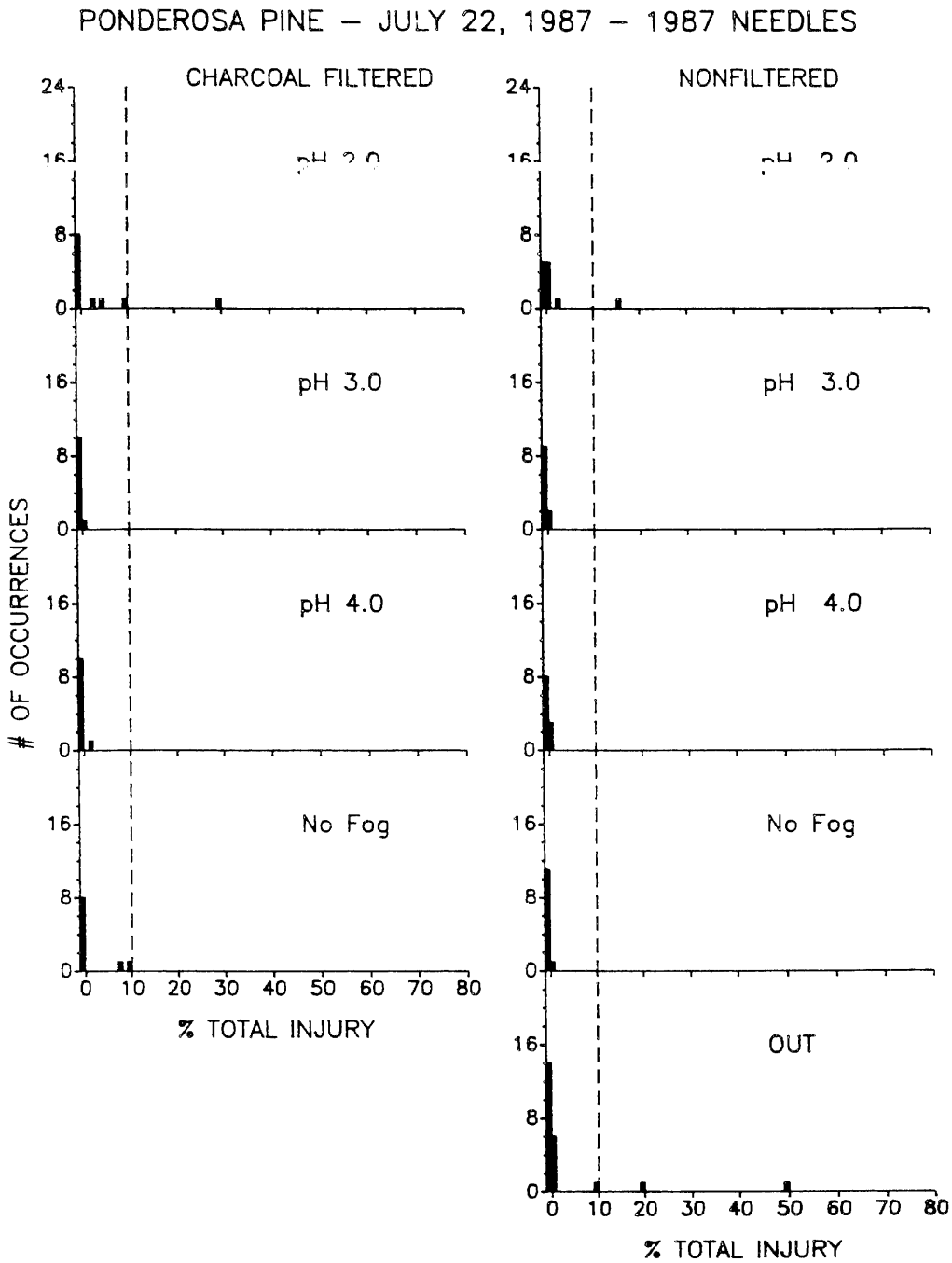

Figure A-10. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1987 needles of ponderosa pine on July 22, 1987 (see Figure A-1 for explanation).

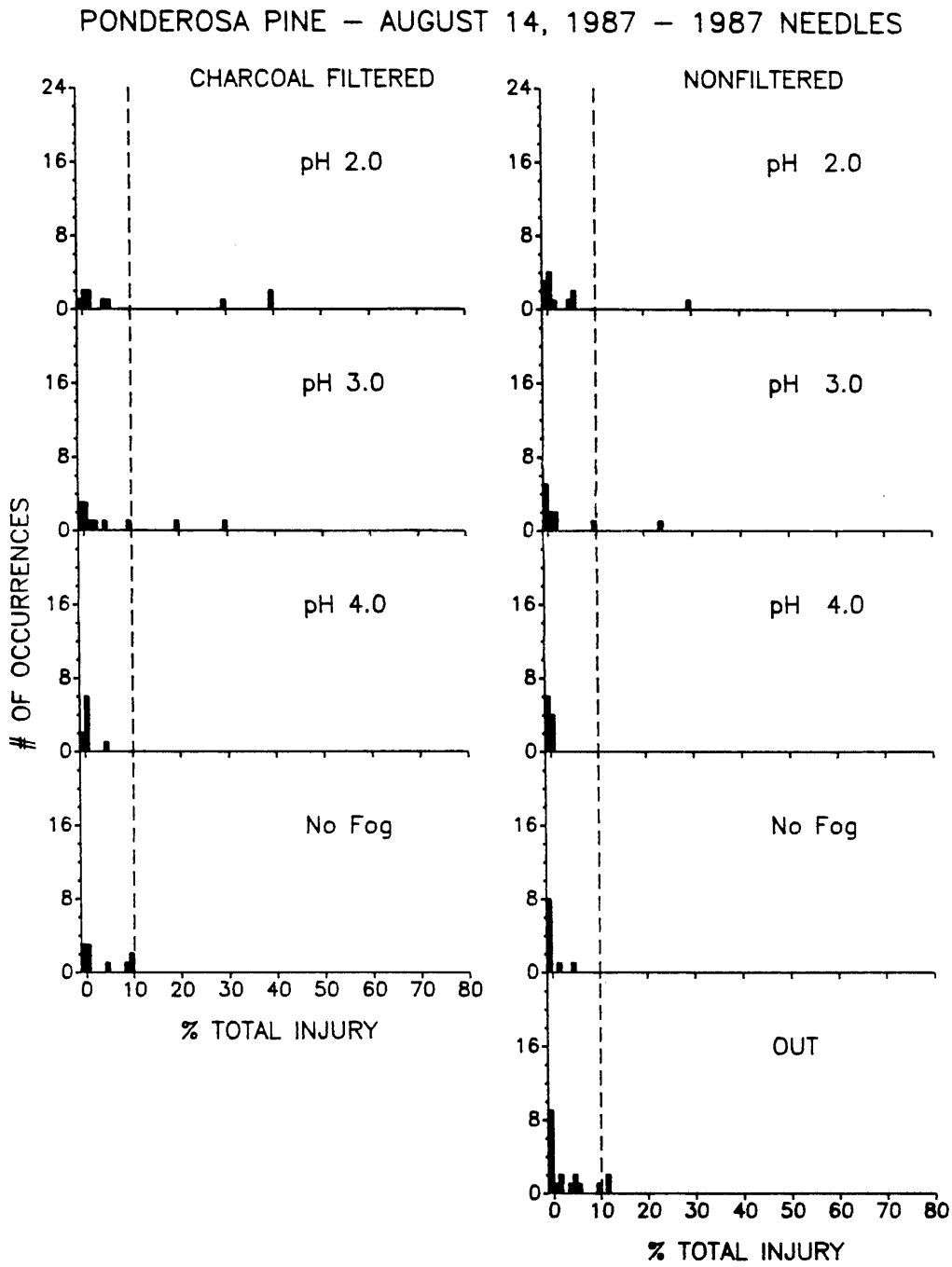

Figure A-11. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1987 needles of ponderosa pine on August 14, 1987 (see Figure A-1 for explanation).

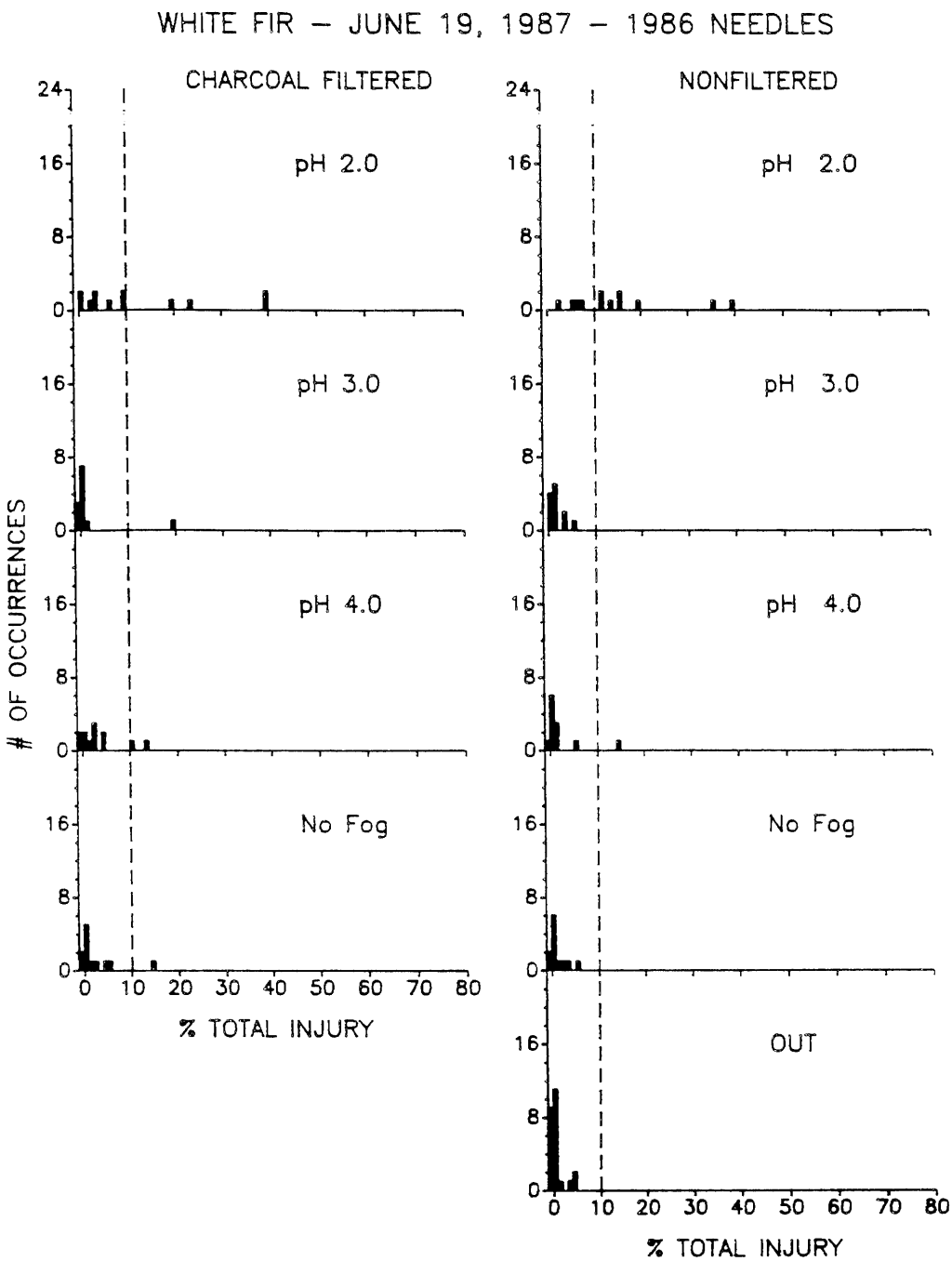

Figure A-12. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1986 needles of white fir on June 19, 1987 (see Figure A-1 for explanation).

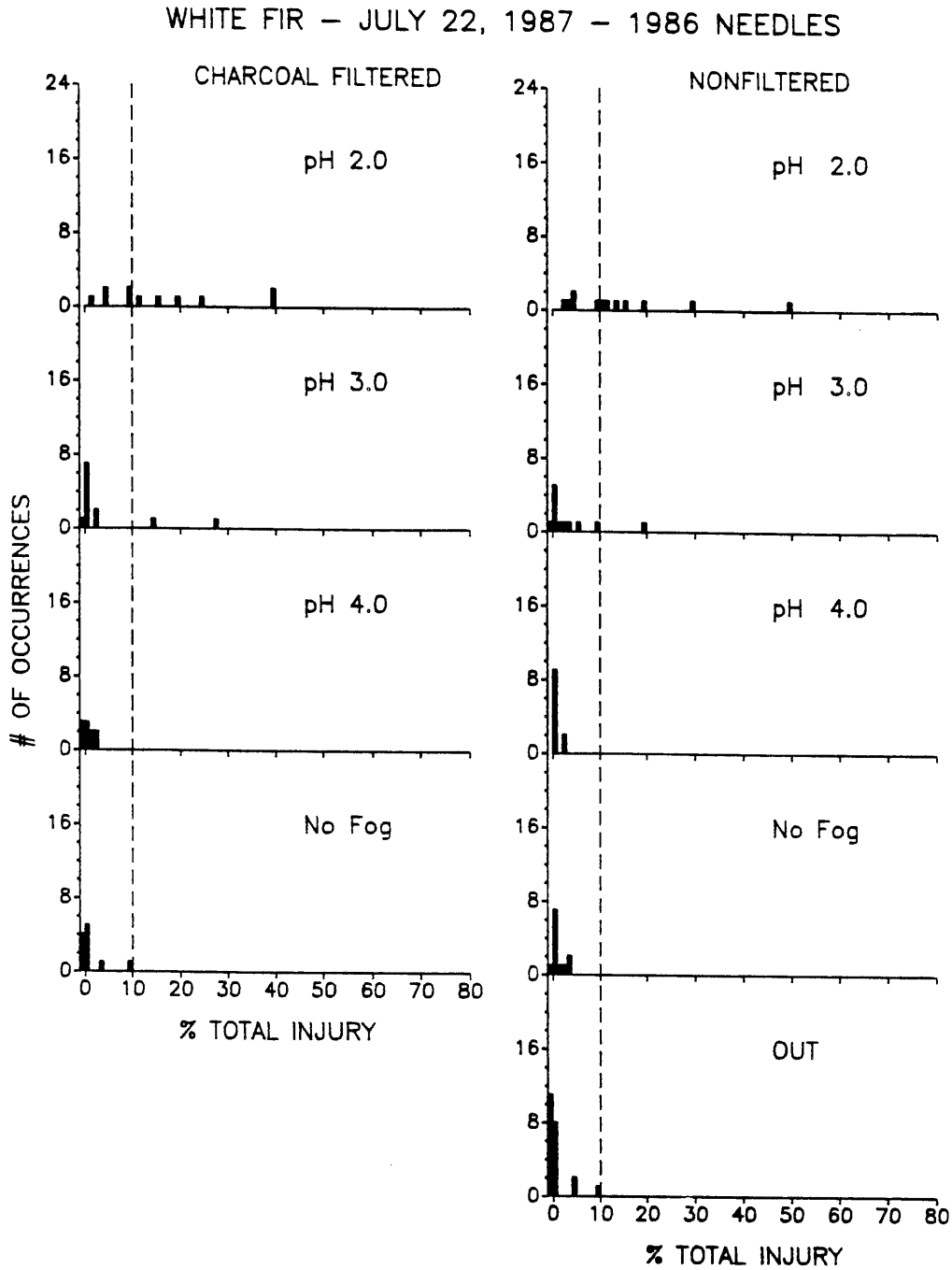

Figure A-13. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1986 needles of white fir on July 22, 1987 (see Figure A-1 for explanation).

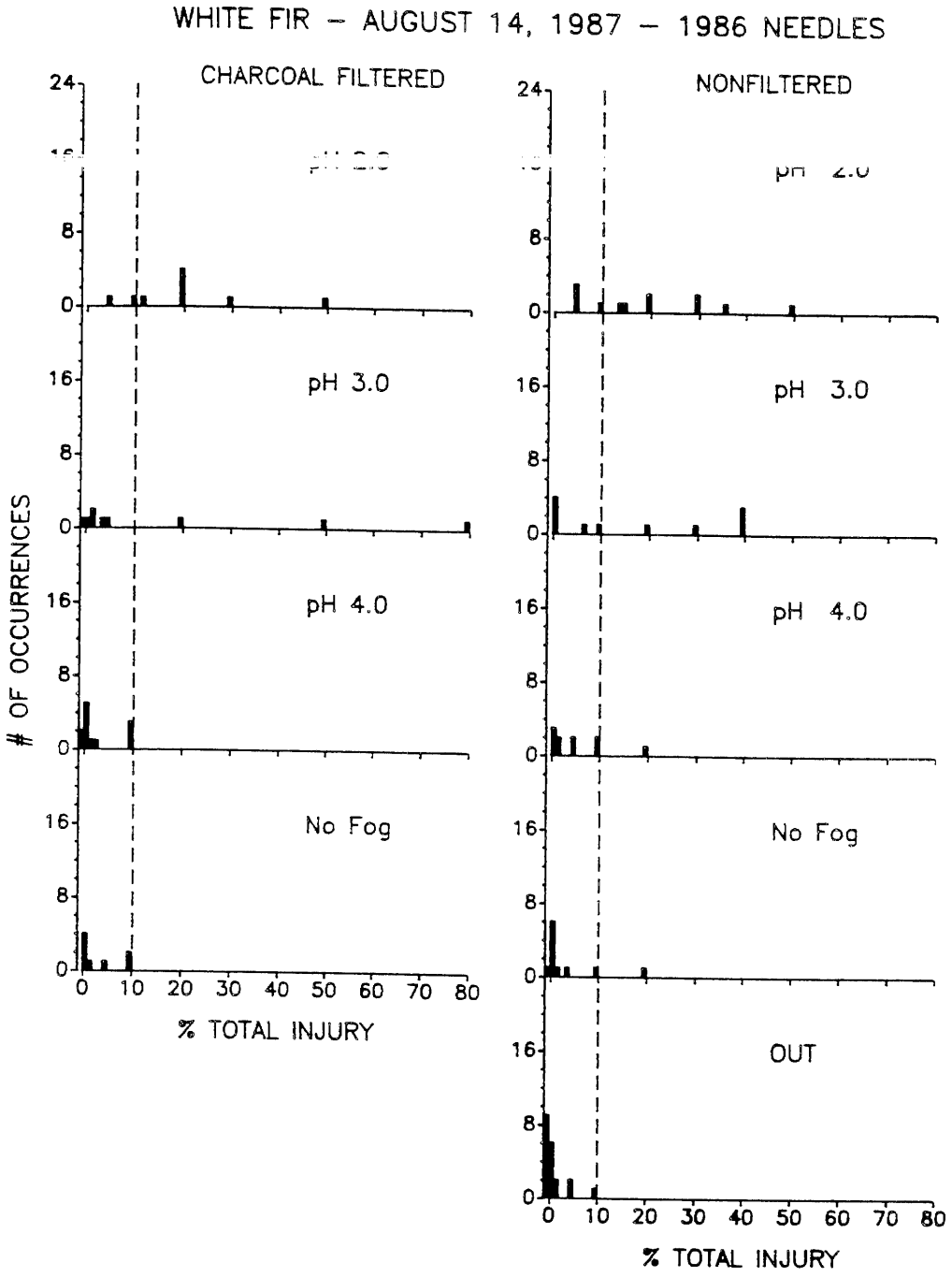

Figure A-14. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1986 needles of white fir on August 14, 1987 (see Figure A-1 for explanation).

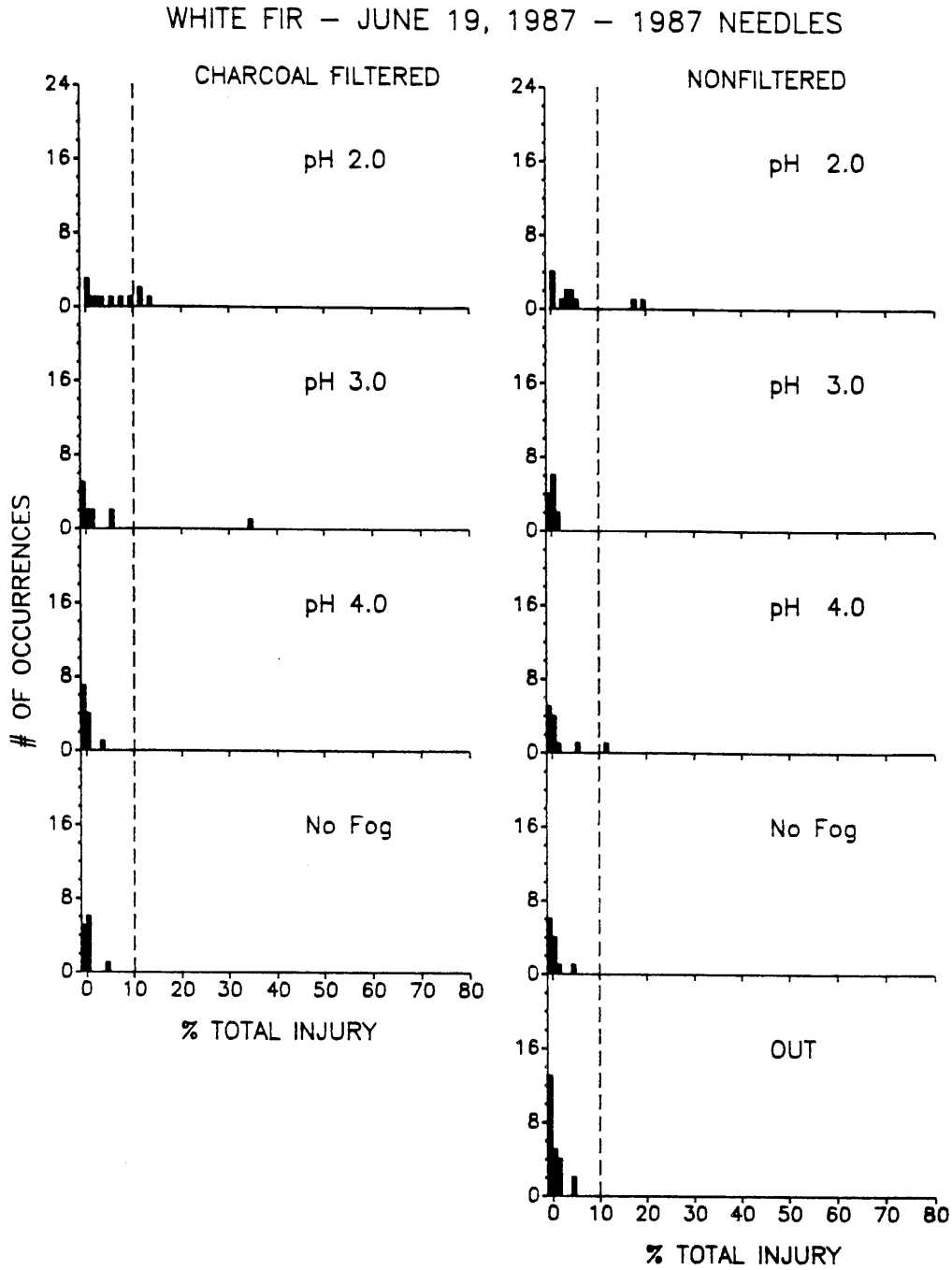

Figure A-15. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1987 needles of white fir on June 19, 1987 (see Figure A-1 for explanation).

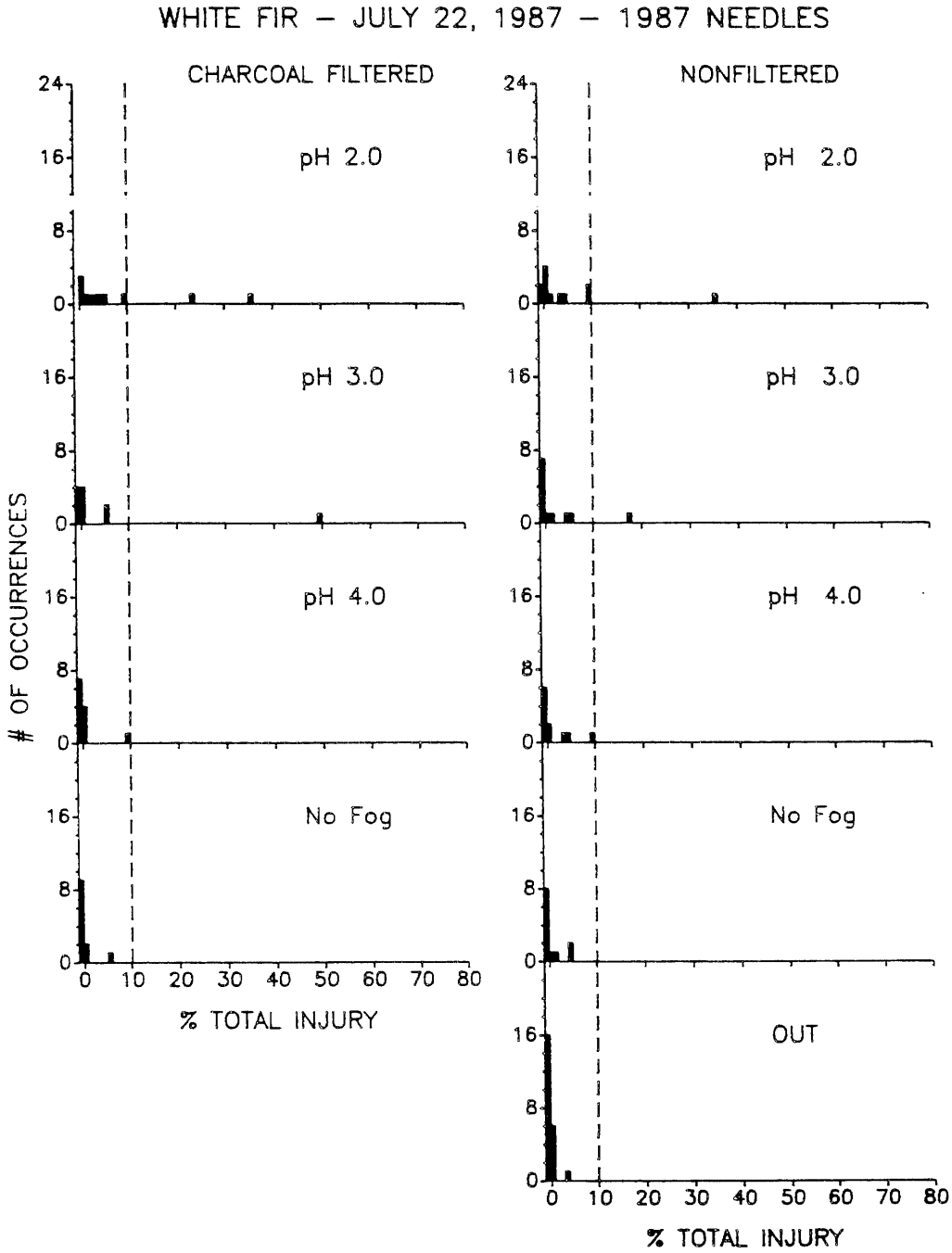

Figure A-16. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1987 needles of white fir on July 22, 1987 (see Figure A-1 for explanation).

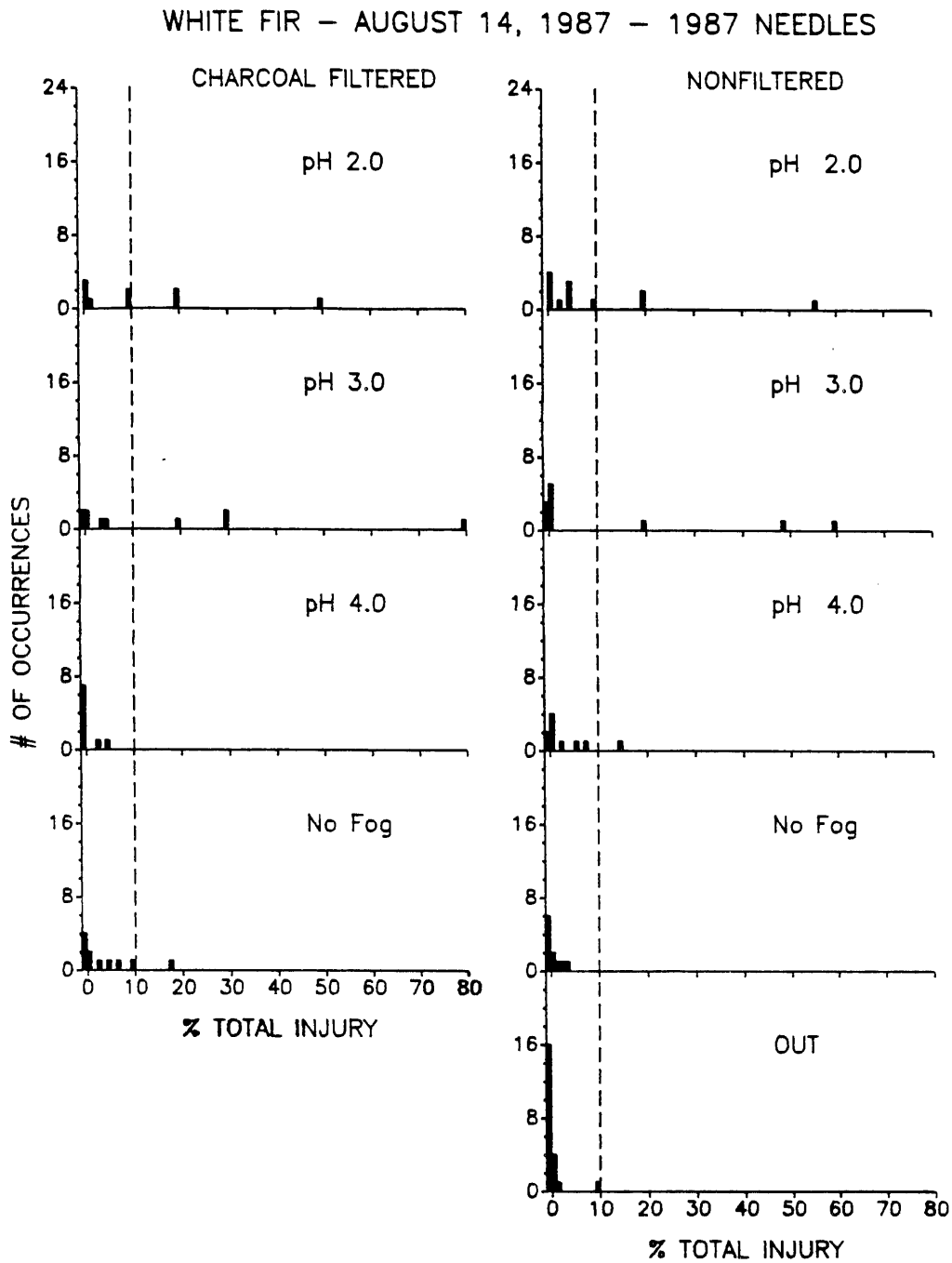

Figure A-17. Combined effects of fog pretreatment and air quality on distribution of injury amounts to 1987 needles of white fir on August 14, 1987 (see Figure A-1 for explanation).

APPENDIX B

Summary Data Tables from the Spring Fog and Summer Ozone Exposure Studies.

Table B-1. The pH of Fog Nozzle Drip Samples on an Event-Basis[a]

Date	Fog No.	pH 4.0	pH 3.0	pH 2.0
10 April	1	5.34 ± 0.99	3.17 ± 0.10	2.17 ± 0.02
13	2	3.81 ± 0.60	3.18 ± 0.04	2.21 ± 0.02
15	3	4.16 ± 0.06	3.13 ± 0.06	2.24 ± 0.02
17	4	4.23 ± 0.05	3.22 ± 0.09	2.16 ± 0.04
20	5	3.95 ± 0.18	3.05 ± 0.02	2.06 ± 0.02
22	6	4.04 ± 0.05	3.02 ± 0.02	1.97 ± 0.02
24	7	4.00 ± 0.01	3.01 ± 0.03	2.09 ± 0.02
27	8	4.01 ± 0.03	3.05 ± 0.06	2.01 ± 0.01
29	9	3.98 ± 0.04	2.97 ± 0.03	2.01 ± 0.01
01 May	10	4.05 ± 0.05	3.05 ± 0.01	1.99 ± 0.01
04	11	4.06 ± 0.05	3.05 ± 0.01	1.97 ± 0.01
06	12	4.01 ± 0.05	3.18 ± 0.02	2.16 ± 0.01
08	13	4.04 ± 0.05	3.16 ± 0.02	2.15 ± 0.01
11	14	4.07 ± 0.06	3.17 ± 0.02	2.14 ± 0.01
13	15	4.04 ± 0.06	3.17 ± 0.02	2.20 ± 0.01
15	16	4.07 ± 0.04	3.17 ± 0.01	2.19 ± 0.01
Mean		4.12 ± 0.34	3.11 ± 0.08	2.11 ± 0.09

[a]Each value represents the average of three sample collections (± one standard deviation).

Table B-2. Environmental Conditions During the Spring Fog Exposure Study[a]

Week	Air Temperature (°C)	Irradiance (μmol m^{-2} s^{-1})	Relative Humidity (%)
14 February	[illegible]	[illegible]	[illegible]
21	18.5	600	21
28	b	b	b
07 March	21.7	569	50
14	20.3	754	41
21	22.6	853	33
28	25.5	915	21
04 April	27.3	984	27
11	28.4	924	29
18	29.8	978	24
25	22.4	767	57
02 May	31.8	899	28
09	27.1	799	53
16	21.8	836	53
Mean[c]	24.4 ± 4.1	814 ± 133	35 ± 14

[a]Mean 12 h value (0800 to 2000 h PST) for each week beginning on the date provided at the ARB Citrus Project Site.
[b]Instrument malfunction.
[c]Mean ± one standard deviation.

Table B-3. Effects of Acidic Fog on Ponderosa Pine Foliar Injury[a]

Fog Treatment	Needle Age Class	
	Young	Old
04 April 1987 (Pre-Exposure)		
pH 2.0	---	2.32 ± 2.61
pH 3.0	---	2.09 ± 1.31
pH 4.0	---	2.03 ± 1.91
No Fog	---	2.04 ± 1.68
ANOVA[b]	---	NS
07 May 1987 (After 11 Fog Exposures)		
pH 2.0	---	5.46 ± 4.17
pH 3.0	---	4.89 ± 5.80
pH 4.0	---	4.80 ± 5.93
No Fog	---	5.67 ± 5.91
ANOVA	---	NS
18 May 1987 (After 16 Fog Exposures)		
pH 2.0	1.13 ± 2.71	5.90 ± 6.27
pH 3.0	3.59 ± 16.43	5.90 ± 8.74
pH 4.0	0.94 ± 3.84	6.35 ± 9.63
No Fog	0.08 ± 0.38	8.90 ± 13.68
ANOVA	NS	NS

[a]Foliar injury expressed as the percentage of the total tree seedling needle surface area exhibiting necrosis (± one standard deviation). Values listed represent the average response of 36 tree seedlings for each fog treatment group.
[b]Results of the ANOVA; NS = not significant at $p < 0.05$.

Table B-4. Effects of Acidic Fog on Stem Height and Diameter in Ponderosa Pine[a]

Fog Treatment	Sampling Period		
	April	May	Post-Fog
Stem Height (mm)			
pH 2.0	289 ± 63	313 ± 70	298 ± 88
pH 3.0	293 ± 54	314 ± 57	307 ± 70
pH 4.0	281 ± 62	297 ± 62	303 ± 75
No Fog	289 ± 56	288 ± 69	302 ± 92
ANOVA[b]	NS	NS	NS
Stem Diameter (mm)			
pH 2.0	6.8 ± 1.4	7.1 ± 1.8	6.9 ± 1.7
pH 3.0	6.7 ± 1.2	7.1 ± 1.7	6.9 ± 2.0
pH 4.0	6.4 ± 1.1	6.6 ± 1.7	6.5 ± 1.8
No Fog	6.9 ± 1.4	6.9 ± 1.7	6.7 ± 2.0
ANOVA	NS	NS	NS

[a]Mean ± one standard deviation. Values represent the average response of 36, 36, and 12 tree seedlings for each fog treatment group for the April, May, and Post-Fog data, respectively. Mean stem height and diameter values prior to the first fog application were 262 ± 68 and 6.2 ± 1.4 mm, respectively, based on a random sample of five seedling trees.
[b]Results of the ANOVA; NS = not significant at $p < 0.05$.

Table B-5. Effects of Acidic Fog on Ponderosa Pine Gas Exchange Rates[a]

Treatment	Sampling Date			
	15 April	20 April	06 May	11 May
Transpiration (mg H_2O m^{-2} s^{-1})				
pH 2.0	21.1 (5.7)	18.0 (8.6)	26.7 (14.7)	31.6 (11.2)
pH 3.0	24.4 (12.8)	25.9 (6.4)	28.4 (11.2)	33.8 (10.7)
pH 4.0	24.8 (5.7)	26.1 (7.6)	36.3 (15.2)	32.7 (12.1)
No Fog	24.8 (9.6)	21.0 (7.1)	37.2 (17.0)	32.4 (5.9)
Stomatal Conductance (cm s^{-1})				
pH 2.0	0.058 (0.02)	0.049 (0.02)	0.049 (0.03)	0.101 (0.03)
pH 3.0	0.070 (0.04)	0.071 (0.02)	0.053 (0.02)	0.113 (0.04)
pH 4.0	0.078 (0.03)	0.076 (0.02)	0.074 (0.04)	0.134 (0.04)
No Fog	0.070 (0.03)	0.060 (0.02)	0.071 (0.04)	0.112 (0.03)
Net Photosynthesis (mg CO_2 m^{-2} s^{-1})				
pH 2.0	0.043 (0.02)	0.083 (0.04)	0.049 (0.04)	0.089 (0.03)
pH 3.0	0.043 (0.03)	0.115 (0.04)	0.057 (0.03)	0.095 (0.05)
pH 4.0	0.060 (0.02)	0.116 (0.02)	0.087 (0.06)	0.095 (0.05)
No Fog	0.058 (0.03)	0.096 (0.03)	0.074 (0.04)	0.111 (0.02)

[a]Values represent the average response of twelve seedlings (± one standard deviation) for each fog treatment group.

Table B-6. Comparison of Injury and Growth Responses of Ponderosa Pine in Outside and No Fog Plots[a]

Parameter	Type of Plot: Outside		Type of Plot: No Fog		t-Test
Injury (% of total leaf area; No Fog data from Appendix B-3)					
April (Old Needles)	2.22	(1.79)	2.04	(1.68)	NS[b]
May (Old Needles)	6.16	(6.11)	5.67	(5.91)	NS
Post-Fog (Old Needles)	7.22	(9.11)	8.90	(13.68)	NS
Post-Fog (Young Needles)	3.53	(17.60)	0.08	(0.38)	NS
Dry Biomass (g; Table 6)					
Root	7.03	(4.53)	7.46	(5.89)	NS
Foliage	5.02	(3.13)	5.24	(2.41)	NS
Stem	5.41	(2.74)	5.67	(2.68)	NS
Shoot	10.43	(5.62)	10.91	(5.04)	NS
Stem Height (mm; Appendix B-4)					
April	287	(62)	289	(56)	NS
May	304	(73)	288	(69)	NS
Post-Fog	295	(91)	302	(92)	NS
Stem Diameter (mm; Appendix B-4)					
April	6.6	(0.9)	6.9	(1.4)	NS
May	6.9	(1.4)	6.9	(1.7)	NS
Post-Fog	6.7	(1.9)	6.7	(2.0)	NS

[a]Mean ± one standard deviation. Values represent the average responses of plants grown in Outside (not enclosed during fog events) and No Fog (enclosed during fog events, but did not receive fog) plots. Sample sizes analyzed are given in previously listed tables.
[b]Results of the t-Test; NS = not significant at $p < 0.05$.

Table B-7. Comparison of Biochemical Responses of Ponderosa Pine in Outside and No Fog Plots[a]

Parameter	Type of Plot: Outside	Type of Plot: No Fog	t-Test
Conductivity (μmhos cm^{-1} g^{-1} dry weight; No Fog data from Table 8)			
Post-Fog (Young Needles)	96 (39)	81 (19)	NS[b]
Post-Fog (Old Needles)	70 (10)	73 (4)	NS
K^+ Leakage (μg K^+ g^{-1} dry weight; Table 8)			
Post-Fog (Young Needles)	823 (253)	751 (161)	NS
Post-Fog (Old Needles)	319 (53)	301 (42)	NS
Total Chlorophyll (mg g^{-1} dry weight; Table 9)			
Post-Fog (Young Needles)	2.68 (0.31)	2.94 (0.66)	NS
Post-Fog (Old Needles)	3.12 (0.24)	2.71 (0.43)	NS
Total Carotenoids (mg g^{-1} dry weight; Table 9)			
Post-Fog (Young Needles)	0.39 (0.05)	0.44 (0.09)	NS
Post-Fog (Old Needles)	0.39 (0.14)	0.37 (0.16)	NS
Starch (mg g^{-1} dry weight; Table 9)			
Post-Fog (Old Needles)	8.39 (6.54)	11.0 (4.1)	NS

[a]Mean ± one standard deviation. Values represent the average responses of plants grown in Outside (not enclosed during fog events) and No Fog (enclosed during fog events, but did not receive fog) plots. Sample sizes analyzed are given in previously listed tables.
[b]Results of the t-Test; NS = not significant at $p < 0.05$.

Table B-8. Effects of Acidic Fog on Stem Height and Diameter in White Fir[a]

Fog Treatment	Sampling Period		
	April	May	Post-Fog
Stem Height (mm)			
pH 2.0	207 ± 45	254 ± 54	254 ± 63
pH 3.0	205 ± 57	255 ± 68	280 ± 77
pH 4.0	209 ± 46	255 ± 48	264 ± 49
No Fog	204 ± 51	254 ± 65	263 ± 97
ANOVA[b]	NS	NS	NS
Stem Diameter (mm)			
pH 2.0	8.0 ± 1.6	8.1 ± 1.5	8.3 ± 1.8
pH 3.0	8.0 ± 1.7	8.2 ± 1.6	8.2 ± 1.6
pH 4.0	7.6 ± 1.5	7.8 ± 1.5	8.5 ± 1.7
No Fog	7.8 ± 1.6	8.2 ± 1.6	8.4 ± 1.6
ANOVA	NS	NS	NS

[a]Mean ± one standard deviation. Values represent the average response of 36, 36, and 12 tree seedlings for each fog treatment group for the April, May, and Post-Fog data, respectively. Mean stem height and diameter values prior to the first fog application were 202 ± 65 and 6.2 ± 1.0 mm, respectively, based on a random sample of five seedling trees.
[b]Results of the ANOVA; NS = not significant at $p < 0.05$.

Table B-9. Effects of Acidic Fog on White Fir Gas Exchange Rates[a]

Treatment	Sampling Date			
	17 April	22 April	08 May	13 May
Transpiration (mg H_2O m^{-2} s^{-1})				
pH 2.0	15.5 (6.5)	22.0 (8.6)	41.9 (14.5)	49.3 (14.3)
pH 3.0	13.2 (6.3)	21.4 (7.6)	35.1 (11.0)	41.5 (12.7)
pH 4.0	15.2 (5.6)	23.0 (6.7)	37.0 (6.4)	50.2 (9.8)
No Fog	15.4 (6.4)	23.0 (7.3)	32.1 (11.4)	40.5 (12.6)
Stomatal Conductance (cm s^{-1})				
pH 2.0	0.062 (0.03)	0.043 (0.02)	0.100 (0.04)	0.162 (0.06)
pH 3.0	0.048 (0.03)	0.041 (0.01)	0.085 (0.02)	0.136 (0.04)
pH 4.0	0.065 (0.02)	0.046 (0.01)	0.104 (0.01)	0.182 (0.05)
No Fog	0.060 (0.03)	0.045 (0.02)	0.076 (0.03)	0.132 (0.05)
Net Photosynthesis (mg CO_2 m^{-2} s^{-1})				
pH 2.0	0.094 (0.04)	0.040 (0.02)	0.048 (0.03)	0.116 (0.05)
pH 3.0	0.071 (0.04)	0.037 (0.02)	0.070 (0.03)	0.122 (0.04)
pH 4.0	0.093 (0.04)	0.045 (0.03)	0.076 (0.03)	0.168 (0.03)
No Fog	0.097 (0.05)	0.044 (0.03)	0.073 (0.03)	0.124 (0.06)

[a]Values represent the average response of twelve seedlings (± one standard deviation) for each fog treatment group.

Table B-10. Comparison of Injury and Growth Responses of White Fir in Outside and No Fog Plots[a]

Parameter	Type of Plot: Outside		Type of Plot: No Fog		t-Test
Injury (% of total leaf area; No fog data from Table 10)					
April (Old Needles)	0.16	(0.43)	0.40	(1.48)	NS[b]
May (Old Needles)	2.14	(6.67)	1.49	(2.71)	NS
Post-Fog (Old Needles)	0.65	(1.15)	1.43	(3.22)	NS
Post-Fog (Young Needles)	1.32	(4.18)	0.33	(1.53)	NS
Dry Biomass (g; Table 11)					
Root	19.19	(7.99)	18.86	(9.43)	NS
Foliage	9.07	(3.28)	8.62	(3.94)	NS
Stem	6.78	(3.32)	6.94	(3.47)	NS
Shoot	15.85	(6.44)	15.55	(7.28)	NS
Stem Height (mm; Appendix B-8)					
April	206	(50)	204	(51)	NS
May	265	(60)	254	(65)	NS
Post-Fog	269	(78)	263	(97)	NS
Stem Diameter (mm; Appendix B-8)					
April	8.1	(1.7)	7.8	(1.6)	NS
May	8.3	(1.3)	8.2	(1.6)	NS
Post-Fog	8.2	(1.7)	8.4	(1.6)	NS

[a]Mean ± one standard deviation. Values represent the average responses of plants grown in Outside (not enclosed during fog events) and No Fog (enclosed during fog events, but did not receive fog) plots. Sample sizes analyzed are given in previously listed tables.
[b]Results of the t-Test; NS = not significant at $p < 0.05$.

Table B-11. Comparison of Biochemical Responses of White Fir in Outside and No Fog Plots[a]

Parameter	Type of Plot: Outside		Type of Plot: No Fog		t-Test
Conductivity (μmhos cm^{-1} g^{-1} dry weight; Table 13)					
Post-Fog (Young Needles)	726	(300)	591	(191)	NS[b]
Post-Fog (Old Needles)	88	(24)	95	(15)	NS
K^+ Leakage (μg K^+ g^{-1} dry weight; Table 13)					
Post-Fog (Young Needles)	1792	(212)	1973	(575)	NS
Post-Fog (Old Needles)	349	(146)	409	(129)	NS
Total Chlorophyll (mg g^{-1} dry weight; Table 14)					
Post-Fog (Young Needles)	2.93	(0.45)	2.45	(0.51)	NS
Post-Fog (Old Needles)	4.71	(0.25)	4.78	(0.62)	NS
Total Carotenoids (mg g^{-1} dry weight; Table 14)					
Post-Fog (Young Needles)	0.59	(0.05)	0.58	(0.05)	NS
Post-Fog (Old Needles)	0.72	(0.10)	0.70	(0.09)	NS
Starch (mg g^{-1} dry weight; Table 14)					
Post-Fog (Old Needles)	21.2	(11.5)	25.4	(4.3)	NS

[a]Mean ± one standard deviation. Values represent the average responses of plants grown in Outside (not enclosed during fog events) and No Fog (enclosed during fog events, but did not receive fog) plots. Sample sizes analyzed are given in previously listed tables.
[b]Results of the t-Test; NS = not significant at $p < 0.05$.

Table B-12. Environmental Conditions During the Summer Ozone Exposure Study[a]

Week	Air Temperature (°C)	Irradiance (μmol m^{-2} s^{-1})	Relative Humidity (%)
23 June	21.1	815	51
30	31.3	1084	32
06 June	26.2	955	56
13	27.0	1026	43
20	28.4	993	47
27	26.3	955	50
04 July	25.5	922	55
11	27.1	946	53
18	26.1	874	44
25	32.3	1013	34
01 August	33.3	892	32
08	28.7	891	49
15	27.2	871	32
22	28.2	881	b
29	32.6	782	b
05 September	29.6	790	b
12	25.5	653	b
19	28.9	658	42
26	29.9	711	b
Mean[c]	28.2 ± 3.0	779 ± 121	44 ± 9

[a]Mean 12 h value (0800 to 2000 h PST) for each week beginning on the date provided at the ARB Citrus Project Site.
[b]Instrument malfunction.
[c]Mean ± one standard deviation.

Table B-13. Statistical Analysis of the Effects of Ozone on Stem Height of Ponderosa Pine Pretreated with Acidic Fog[a]

Treatment Variable	Month of Sampling			
	June	July	August	September
Air Quality[b] (AQ)				
CF	330 (52)	338 (51)	351 (48)	352 (43)
NF	337 (60)	346 (52)	354 (53)	354 (51)
Fog Pretreatment[c] (FP)				
pH 2.0	344 (57)	351 (58)	361 (54)	361 (55)
pH 3.0	346 (47)	351 (45)	361 (44)	355 (42)
pH 4.0	319 (61)	334 (51)	346 (48)	348 (40)
No Fog	326 (57)	334 (51)	343 (54)	348 (51)
AQ x FP				
CF/pH 2.0	344 (42)	351 (46)	366 (33)	366 (31)
NF/pH 2.0	344 (70)	350 (70)	356 (70)	356 (73)
CF/pH 3.0	338 (50)	345 (49)	355 (49)	351 (50)
NF/pH 3.0	353 (45)	357 (43)	367 (39)	359 (34)
CF/pH 4.0	322 (52)	328 (56)	343 (51)	352 (33)
NF/pH 4.0	315 (71)	340 (47)	349 (48)	344 (47)
CF/No Fog	316 (63)	330 (54)	342 (56)	339 (55)
NF/No Fog	336 (52)	338 (50)	345 (55)	356 (48)
ANOVA Effect[d]				
AQ	NS	NS	NS	NS
FP	NS	NS	NS	NS
AQ x FP	NS	NS	NS	NS
C.V. (%)[e]	18.0	16.5	15.7	15.8

[a]Mean (± one standard deviation) in mm. Sample sizes of 48, 24, and 12 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-14. Statistical Analysis of the Effects of Ozone on Stem Diameter of Ponderosa Pine Pretreated with Acidic Fog[a]

Treatment Variable	Month of Sampling			
	June	July	August	September
Air Quality[b] (AQ)				
CF	8.2 (1.6)	8.6 (1.5)	9.0 (1.7)	9.2 (1.3)
NF	8.5 (1.9)	9.1 (1.6)	9.3 (1.8)	9.6 (1.3)
Fog Pretreatment[c] (FP)				
pH 2.0	8.7 (1.7)	8.9 (1.7)	9.1 (1.7)	9.3 (1.3)
pH 3.0	8.7 (1.3)	9.0 (1.2)	9.2 (1.7)	9.5 (1.3)
pH 4.0	8.0 (1.8)	8.6 (1.7)	9.1 (1.7)	9.4 (1.0)
No Fog	8.2 (2.0)	8.7 (1.8)	9.1 (2.0)	9.4 (1.6)
AQ x FP				
CF/pH 2.0	8.6 (1.7)	8.8 (1.4)	8.9 (1.7)	9.3 (1.0)
NF/pH 2.0	8.7 (1.8)	9.0 (2.0)	9.2 (1.8)	9.3 (1.5)
CF/pH 3.0	8.5 (1.4)	8.8 (1.3)	9.3 (1.8)	9.3 (1.6)
NF/pH 3.0	8.9 (1.1)	9.2 (1.1)	9.2 (1.8)	9.7 (0.9)
CF/pH 4.0	7.8 (1.3)	8.1 (1.8)	8.7 (1.9)	9.2 (1.0)
NF/pH 4.0	8.2 (2.2)	9.1 (1.4)	9.5 (1.6)	9.6 (1.1)
CF/No Fog	7.8 (1.9)	8.4 (1.5)	8.9 (1.6)	9.0 (1.6)
NF/No Fog	8.5 (2.2)	9.0 (2.1)	9.3 (2.4)	9.8 (1.6)
ANOVA Effect[d]				
AQ	NS	NS	NS	NS
FP	NS	NS	NS	NS
AQ x FP	NS	NS	NS	NS
C.V. (%)[e]	19.7	18.0	19.0	14.2

[a]Mean (± one standard deviation) in mm. Sample sizes of 48, 24, and 12 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-15. Statistical Analysis of the Effects of Ozone on the Chlorophyll Content of Ponderosa Pine Needles Pretreated with Acidic Fog[a]: June 1987

Treatment Variable	Needle Age Class	
	Young	Old
Air Quality[b] (AQ)		
CF	2.38 ± 0.59	4.12 ± 1.04
NF	2.60 ± 0.66	4.10 ± 1.07
Fog Pretreatment[c] (FP)		
pH 2.0	2.38 ± 0.74	4.36 ± 1.20
pH 3.0	2.37 ± 0.70	4.07 ± 1.10
pH 4.0	2.58 ± 0.50	3.90 ± 1.11
No Fog	2.53 ± 0.57	4.12 ± 0.77
AQ x FP		
CF/pH 2.0	2.16 ± 0.61	4.37 ± 1.22
NF/pH 2.0	2.61 ± 0.84	4.35 ± 1.26
CF/pH 3.0	2.31 ± 0.68	4.22 ± 1.18
NF/pH 3.0	2.44 ± 0.77	3.93 ± 1.07
CF/pH 4.0	2.58 ± 0.55	3.94 ± 1.06
NF/pH 4.0	2.58 ± 0.49	3.86 ± 1.23
CF/No Fog	2.47 ± 0.53	3.96 ± 0.78
NF/No Fog	2.79 ± 0.59	4.28 ± 0.79
ANOVA Effect[d]		
AQ	NS	NS
FP	NS	NS
AQ x FP	NS	NS
C.V. (%)[e]	23.0	27.9

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 32, 16, and 8 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-16. Statistical Analysis of the Effects of Ozone on the Chlorophyll Content of Ponderosa Pine Needles Pretreated with Acidic Fog[a]: July 1987

Treatment Variable	Needle Age Class	
	Young	Old
Air Quality[b] (AQ)		
CF	2.52 ± 0.65	3.18 ± 1.07
NF	2.61 ± 0.69	3.22 ± 1.18
Fog Pretreatment[c] (FP)		
pH 2.0	2.44 ± 0.85	3.27 ± 0.86
pH 3.0	2.52 ± 0.47	3.02 ± 1.35
pH 4.0	2.60 ± 0.71	3.27 ± 0.97
No Fog	2.70 ± 0.62	3.24 ± 1.31
AQ x FP		
CF/pH 2.0	2.49 ± 0.91	3.22 ± 0.88
NF/pH 2.0	2.38 ± 0.84	3.33 ± 0.89
CF/pH 3.0	2.33 ± 0.52	2.92 ± 1.03
NF/pH 3.0	2.72 ± 0.34	3.11 ± 1.69
CF/pH 4.0	2.61 ± 0.55	3.22 ± 1.07
NF/pH 4.0	2.59 ± 0.88	3.33 ± 0.92
CF/No Fog	2.63 ± 0.62	3.35 ± 1.40
NF/No Fog	2.76 ± 0.65	3.12 ± 1.29
ANOVA Effect[d]		
AQ	NS	NS
FP	NS	NS
AQ x FP	NS	NS
C.V. (%)[e]	25.3	31.1

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 32, 16, and 8 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-17. Statistical Analysis of the Effects of Ozone on the Chlorophyll Content of Ponderosa Pine Needles Pretreated with Acidic Fog[a]: August 1987

Treatment Variable	Needle Age Class	
	Young	Old
Air Quality[b] (AQ)		
CF	2.53 ± 0.84	2.78 ± 0.92
NF	2.51 ± 0.98	2.40 ± 0.67
Fog Pretreatment[c] (FP)		
pH 2.0	2.42 ± 0.69	2.72 ± 0.79 y
pH 3.0	2.45 ± 0.99	2.70 ± 1.14 y
pH 4.0	2.40 ± 0.93	2.75 ± 0.66 y
No Fog	2.80 ± 1.01	2.19 ± 0.50 z
L.S.D.[d]	---	0.24
AQ x FP		
CF/pH 2.0	2.56 ± 0.39	2.88 ± 0.72
NF/pH 2.0	2.28 ± 0.91	2.57 ± 0.87
CF/pH 3.0	2.56 ± 1.17	3.10 ± 1.38
NF/pH 3.0	2.34 ± 0.85	2.30 ± 0.71
CF/pH 4.0	2.52 ± 1.17	2.94 ± 0.61
NF/pH 4.0	2.28 ± 0.66	2.57 ± 0.70
CF/No Fog	2.47 ± 0.47	2.19 ± 0.63
NF/No Fog	3.13 ± 1.31	2.18 ± 0.37
ANOVA Effect[e]		
AQ	NS	NS
FP	NS	**
AQ x FP	*	NS
C.V. (%)[f]	33.0	35.6

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 32, 16, and 8 were used to examine the AQ, FP, and AQ x FP effects, respectively. Dissimilar letter designations indicate significant differences at $p < 0.05$ (Duncan's New Multiple Range Test).
[b]NF = nonfiltered air; CF = charcoal-filtered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]L.S.D. = least significant difference between a pair of means in the set (2-sample t-test, 5% level).
[e]Results of the ANOVA; NS = not significant at $p < 0.05$, * = significant at $p < 0.05$.
[f]C.V. = coefficient of variation.

Table B-18. Statistical Analysis of the Effects of Ozone on the Carotenoid Content of Ponderosa Pine Needles Pretreated with Acidic Fog[a]: June 1987

Treatment Variable	Needle Age Class	
	Young	Old
Air Quality[b] (AQ)		
CF	0.24 ± 0.06	0.36 ± 0.10
NF	0.27 ± 0.10	0.35 ± 0.11
Fog Pretreatment[c] (FP)		
pH 2.0	0.26 ± 0.09	0.33 ± 0.09
pH 3.0	0.24 ± 0.08	0.35 ± 0.11
pH 4.0	0.25 ± 0.08	0.36 ± 0.08
No Fog	0.27 ± 0.09	0.37 ± 0.14
AQ x FP		
CF/pH 2.0	0.24 ± 0.05	0.33 ± 0.09
NF/pH 2.0	0.27 ± 0.11	0.34 ± 0.10
CF/pH 3.0	0.24 ± 0.06	0.37 ± 0.08
NF/pH 3.0	0.24 ± 0.10	0.34 ± 0.13
CF/pH 4.0	0.23 ± 0.08	0.38 ± 0.09
NF/pH 4.0	0.27 ± 0.08	0.34 ± 0.08
CF/No Fog	0.24 ± 0.05	0.38 ± 0.16
NF/No Fog	0.30 ± 0.11	0.37 ± 0.13
ANOVA Effect[d]		
AQ	NS	NS
FP	NS	NS
AQ x FP	NS	NS
C.V. (%)[e]	34.5	34.6

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 32, 16, and 8 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-19. Statistical Analysis of the Effects of Ozone on the Carotenoid Content of Ponderosa Pine Needles Pretreated with Acidic Fog[a]: July 1987

Treatment Variable	Needle Age Class	
	Young	Old
Air Quality[b] (AQ)		
CF	0.29 ± 0.13	0.31 ± 0.16
NF	0.25 ± 0.12	0.31 ± 0.14
Fog Pretreatment[c] (FP)		
pH 2.0	0.29 ± 0.13	0.33 ± 0.16
pH 3.0	0.27 ± 0.12	0.27 ± 0.15
pH 4.0	0.28 ± 0.15	0.30 ± 0.14
No Fog	0.25 ± 0.09	0.34 ± 0.17
AQ x FP		
CF/pH 2.0	0.34 ± 0.13	0.35 ± 0.15
NF/pH 2.0	0.24 ± 0.11	0.31 ± 0.17
CF/pH 3.0	0.29 ± 0.14	0.26 ± 0.15
NF/pH 3.0	0.24 ± 0.10	0.29 ± 0.16
CF/pH 4.0	0.30 ± 0.14	0.30 ± 0.14
NF/pH 4.0	0.27 ± 0.17	0.30 ± 0.14
CF/No Fog	0.25 ± 0.08	0.34 ± 0.21
NF/No Fog	0.26 ± 0.11	0.33 ± 0.13
ANOVA Effect[d]		
AQ	NS	NS
FP	NS	NS
AQ x FP	NS	NS
C.V. (%)[e]	51.0	58.5

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 32, 16, and 8 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-20. Statistical Analysis of the Effects of Ozone on the Carotenoid Content of Ponderosa Pine Needles Pretreated with Acidic Fog[a]: August 1987

Treatment Variable	Needle Age Class	
	Young	Old
Air Quality[b] (AQ)		
CF	0.22 ± 0.11	0.22 ± 0.12
NF	0.19 ± 0.10	0.18 ± 0.08
Fog Pretreatment[c] (FP)		
pH 2.0	0.21 ± 0.09	0.20 ± 0.08
pH 3.0	0.20 ± 0.09	0.20 ± 0.11
pH 4.0	0.18 ± 0.09	0.23 ± 0.14
No Fog	0.23 ± 0.14	0.16 ± 0.06
AQ x FP		
CF/pH 2.0	0.25 ± 0.10 yz	0.22 ± 0.09
NF/pH 2.0	0.16 ± 0.06 z	0.18 ± 0.07
CF/pH 3.0	0.24 ± 0.10 yz	0.22 ± 0.11
NF/pH 3.0	0.17 ± 0.05 z	0.17 ± 0.12
CF/pH 4.0	0.21 ± 0.11 yz	0.27 ± 0.18
NF/pH 4.0	0.16 ± 0.06 z	0.19 ± 0.05
CF/No Fog	0.18 ± 0.12 yz	0.15 ± 0.04
NF/No Fog	0.28 ± 0.15 y	0.16 ± 0.07
L.S.D.[d]	0.98	---
ANOVA Effect[e]		
AQ	NS	NS
FP	NS	NS
AQ x FP	*	NS
C.V. (%)[f]	41.1	46.2

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 32, 16, and 8 were used to examine the AQ, FP, and AQ x FP effects, respectively. Dissimilar letter designations indicate significant differences at $p<0.05$ (Duncan's New Multiple Range Test).
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]L.S.D. = least significant difference between a pair of means in the set (2-sample t-test, 5% level).
[e]Results of the ANOVA; NS = not significant at $p<0.05$, * = significant at $p<0.05$.
[f]C.V. = coefficient of variation.

Table B-21. Statistical Analysis of the Effects of Ozone on the Starch Content of Ponderosa Pine Pretreated with Acidic Fog[a]

Treatment Variable	Ponderosa Pine
Air Quality[b] (AQ)	
CF	3.13 ± 0.67
NF	2.97 ± 0.65
Fog Pretreatment[c] (FP)	
pH 2.0	3.12 ± 0.53
pH 3.0	3.08 ± 0.74
pH 4.0	3.30 ± 0.72
No Fog	2.69 ± 0.56
AQ x FP	
CF/pH 2.0	3.12 ± 0.72
NF/pH 2.0	3.12 ± 0.34
CF/pH 3.0	3.21 ± 0.28
NF/pH 3.0	2.95 ± 1.07
NF/pH 4.0	3.50 ± 0.90
NF/pH 4.0	3.09 ± 0.54
CF/No Fog	2.67 ± 0.58
NF/No Fog	2.71 ± 0.62
ANOVA Effect[d]	
AQ	NS
FP	NS
AQ x FP	NS
C.V. (%)[e]	45.5

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 16, 8, and 4 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p < 0.05$.
[e]C.V. = coefficient of variation.

Table B-22. Comparison of Growth Responses of Ponderosa Pine in Outside and Nonfiltered-No Fog Plots[a]

Parameter	Type of Plot: Outside	Type of Plot: Nonfiltered-No Fog	t-Test
Injury (% of total leaf area)			
June (Young Needles)	0.52 (2.14)	0.02 (0.06)	NS[b]
July (Young Needles)	3.61 (11.09)	0.09 (0.30)	NS
August (Young Needles)	8.86 (14.62)	0.50 (1.58)	NS
June (Old Needles)	26.27 (31.83)	6.08 (5.20)	*
July (Old Needles)	24.00 (30.54)	12.50 (12.88)	NS
August (Old Needles)	28.53 (34.65)	19.09 (14.86)	NS
Stem Height (mm; NF- No fog data from Appendix B-13)			
June	343 (57)	336 (52)	NS
July	346 (58)	338 (50)	NS
August	356 (54)	345 (55)	NS
September	362 (60)	356 (50)	NS
Stem Diameter (mm; Appendix B-14)			
June	8.4 (1.1)	8.5 (2.2)	NS
July	8.9 (1.3)	9.0 (2.1)	NS
August	9.6 (1.0)	9.3 (2.4)	NS
September	10.1 (1.3)	9.8 (1.7)	NS
Dry Biomass (g; Table 16)			
Root	15.50 (6.17)	15.74 (7.79)	NS
Stem	11.07 (3.23)	9.86 (3.83)	NS
Needles	11.41 (4.79)	13.64 (6.52)	NS
Shoot	22.47 (7.66)	23.49 (10.25)	NS

[a]Mean (± one standard deviation). Values represent the average responses of plants grown in Outside (not grown in field chambers) and Nonfiltered-No Fog (exposed to ambient air and no fog pretreatment) plots. Sample sizes for each parameter are provided in previously presented tables.
[b]Results of the t-Test; NS = not significant at $p<0.05$, * = significant at $p<0.05$.

Table B-23. Comparison of Biochemical Responses of Ponderosa Pine in Outside and Nonfiltered-No Fog Plots[a]

Parameter	Type of Plot: Outside	Type of Plot: Nonfiltered-No Fog	t-Test
Conductivity (μmhos cm^{-1} g^{-1} dry weight; NF-No fog data from Table 19)			
September (Young Needles)	1152 (172)	1332 (103)	NS
September (Old Needles)	982 (89)	1504 (341)	*
K^+ Leakage (μg g^{-1} dry weight; Table 20)			
September (Young Needles)	4655 (765)	8307 (1589)	*
September (Old Needles)	3691 (1287)	5869 (1287)	*
Total Chlorophyll (mg g^{-1} dry weight; Appendices B-15 to B-17, Table 21)			
June (Young Needles)	2.30 (0.44)	2.79 (0.59)	NS
July (Young Needles)	2.35 (0.50)	2.76 (0.65)	NS
August (Young Needles)	2.09 (0.65)	3.13 (1.31)	NS
September (Young Needles)	2.93 (0.67)	2.79 (0.58)	NS
June (Old Needles)	2.87 (0.88)	4.28 (0.79)	NS
July (Old Needles)	3.65 (0.79)	3.12 (1.29)	NS
August (Old Needles)	2.44 (0.50)	2.18 (0.37)	NS
September (Old Needles)	3.00 (0.80)	3.56 (0.40)	NS
Total Carotenoids (mg g^{-1} dry weight; Appendices B-18 to B-120, Table 22)			
June (Young Needles)	0.22 (0.03)	0.30 (0.11)	NS
July (Young Needles)	0.29 (0.11)	0.26 (0.11)	NS
August (Young Needles)	0.16 (0.04)	0.28 (0.15)	*
September (Young Needles)	0.32 (0.04)	0.30 (0.70)	NS
June (Old Needles)	0.29 (0.03)	0.37 (0.13)	NS
July (Old Needles)	0.35 (0.21)	0.33 (0.13)	NS
August (Old Needles)	0.18 (0.09)	0.16 (0.07)	NS
September (Old Needles)	0.40 (0.04)	0.39 (0.06)	NS
Starch (mg g^{-1} dry weight; Appendix B-21)			
September (Old Needles)	4.02 (1.06)	2.71 (0.62)	NS

[a]Mean (± one standard deviation). Values represent the average responses of plants grown in Outside (not grown in field chambers) and Nonfiltered-No Fog (exposed to ambient air and no fog pretreatment) plots. Sample sizes for each parameter are provided in previously presented tables.
[b]Results of the t-Test; NS = not significant at $p<0.05$, * = significant at $p<0.05$.

Table B-24. Statistical Analysis of the Effects of Ozone on Stem Height of White Fir Pretreated with Acidic Fog[a]

Treatment Variable	Month of Sampling			
	June	July	August	September
Air Quality[b] (AQ)				
CF	262 (58)	271 (56)	284 (57)	285 (56)
NF	271 (59)	277 (58)	287 (58)	289 (56)
Fog Pretreatment[c] (FP)				
pH 2.0	278 (57)	282 (57)	297 (61)	298 (59)
pH 3.0	256 (60)	267 (62)	279 (55)	289 (54)
pH 4.0	267 (59)	281 (52)	290 (54)	290 (54)
No Fog	264 (58)	267 (57)	275 (57)	270 (57)
AQ x FP				
CF/pH 2.0	266 (40)	268 (38)	288 (44)	290 (38)
NF/pH 2.0	290 (69)	296 (70)	306 (76)	306 (75)
CF/pH 3.0	255 (64)	277 (67)	287 (62)	300 (59)
NF/pH 3.0	256 (59)	256 (57)	271 (50)	277 (47)
CF/pH 4.0	270 (67)	280 (60)	287 (64)	284 (63)
NF/pH 4.0	265 (53)	283 (45)	293 (44)	296 (45)
CF/No Fog	256 (63)	261 (58)	274 (61)	265 (61)
NF/No Fog	272 (55)	273 (57)	276 (56)	275 (55)
ANOVA Effect[d]				
AQ	NS	NS	NS	NS
FP	NS	NS	NS	NS
AQ x FP	NS	NS	NS	NS
C.V. (%)[e]	22.7	21.3	20.5	20.2

[a]Mean (± one standard deviation) in mm. Sample sizes of 48, 24, and 12 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-25. Statistical Analysis of the Effects of Ozone on Mycorrhizal Colonization of White Fir Pretreated with Acidic Fog[a]

Treatment Variable	% Infection	No. of Short Roots cm^{-1}	No. of Infected Roots cm^{-1}
Air Quality[b] (AQ)			
CF	21.92 (8.66)	2.96 (1.05)	0.98 (0.50)
NF	18.20 (12.60)	3.10 (0.85)	0.63 (0.42)
Fog Pretreatment[c] (FP)			
pH 2.0	27.70 (10.17)	2.96 (0.87)	0.94 (0.40)
pH 3.0	18.17 (8.81)	2.60 (0.58)	0.77 (0.49)
pH 4.0	16.64 (12.42)	3.16 (1.26)	0.73 (0.63)
No Fog	17.73 (9.54)	3.40 (0.94)	0.80 (0.48)
AQ x FP			
CF/pH 2.0	23.05 (12.44)	2.86 (1.14)	0.86 (0.51)
NF/pH 2.0	32.35 (5.37)	3.06 (0.67)	1.01 (0.31)
CF/pH 3.0	18.18 (8.01)	2.45 (0.81)	0.93 (0.58)
NF/pH 3.0	18.17 (10.82)	2.76 (0.24)	0.61 (0.41)
CF/pH 4.0	21.48 (10.06)	2.64 (1.32)	1.06 (0.64)
NF/pH 4.0	11.80 (14.01)	3.67 (1.11)	0.40 (0.47)
CF/No Fog	24.98 (4.62)	3.89 (0.40)	1.07 (0.45)
NF/No Fog	10.48 (7.13)	2.91 (1.12)	0.52 (0.36)
ANOVA Effect[d]			
AQ	NS	NS	NS
FP	NS	NS	NS
AQ x FP	NS	NS	NS
C.V. (%)[e]	57.6	28.1	39.2

[a]Mean (± one standard deviation) for % infection, no. of short roots cm^{-1} of lateral root, and no. of infected roots cm^{-1} of lateral root. Sample sizes of 48, 24, and 12 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-26. Statistical Analysis of the Effects of Ozone on the Chlorophyll Content of White Fir Needles Pretreated with Acidic Fog[a]: July 1987

Treatment Variable	Needle Age Class	
	Young	Old
Air Quality[b] (AQ)		
CF	1.81 ± 0.41	4.18 ± 0.87
NF	1.79 ± 0.31	4.52 ± 0.70
Fog Pretreatment[c] (FP)		
pH 2.0	1.87 ± 0.27	4.25 ± 0.83
pH 3.0	1.84 ± 0.34	4.26 ± 0.92
pH 4.0	1.66 ± 0.30	4.57 ± 0.72
No Fog	1.84 ± 0.49	4.32 ± 0.74
AQ x FP		
CF/pH 2.0	1.80 ± 0.33	3.68 ± 0.65 z
NF/pH 2.0	1.93 ± 0.21	4.83 ± 0.54 x
CF/pH 3.0	1.73 ± 0.25	3.46 ± 0.29 z
NF/pH 3.0	1.95 ± 0.39	5.06 ± 0.54 x
CF/pH 4.0	1.60 ± 0.35	4.86 ± 0.68 x
NF/pH 4.0	1.72 ± 0.26	4.29 ± 0.68 xyz
CF/No Fog	2.10 ± 0.55	4.73 ± 0.78 xy
NF/No Fog	1.58 ± 0.23	3.91 ± 0.44 yz
L.S.D.[d]	---	0.84
ANOVA Effect[e]		
AQ	NS	NS
FP	NS	NS
AQ x FP	NS	*
C.V. (%)[f]	13.6	12.0

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 32, 16, and 8 were used to examine the AQ, FP, and AQ x FP effects, respectively. Dissimilar letter designations indicate significant differences at $p<0.05$ (Duncan's New Multiple Range Test).
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]L.S.D. = least significant difference between a pair of means in the set (2-sample t-test, 5% level).
[e]Results of the ANOVA; NS = not significant at $p<0.05$, * = significant at $p<0.05$.
[f]C.V. = coefficient of variation.

Table B-27. Statistical Analysis of the Effects of Ozone on the Chlorophyll Content of White Fir Needles Pretreated with Acidic Fog[a]: August 1987

Treatment Variable	Needle Age Class	
	Young	Old
Air Quality[b] (AQ)		
CF	1.90 ± 0.62	3.88 ± 0.69
NF	1.87 ± 0.53	3.94 ± 0.82
Fog Pretreatment[c] (FP)		
pH 2.0	1.65 ± 0.54	3.94 ± 0.83
pH 3.0	2.00 ± 0.54	3.77 ± 0.71
pH 4.0	2.01 ± 0.64	4.09 ± 0.95
No Fog	1.88 ± 0.54	3.83 ± 0.49
AQ x FP		
CF/pH 2.0	1.34 ± 0.36	3.85 ± 1.02
NF/pH 2.0	1.96 ± 0.53	4.04 ± 0.63
CF/pH 3.0	1.91 ± 0.34	3.52 ± 0.65
NF/pH 3.0	2.09 ± 0.70	4.02 ± 0.71
CF/pH 4.0	2.17 ± 0.73	4.15 ± 0.37
NF/pH 4.0	1.85 ± 0.55	4.03 ± 1.33
CF/No Fog	2.18 ± 0.61	4.00 ± 0.50
NF/No Fog	1.57 ± 0.16	3.66 ± 0.44
ANOVA Effect[d]		
AQ	NS	NS
FP	NS	NS
AQ x FP	NS	NS
C.V. (%)[e]	14.9	13.7

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 32, 16, and 8 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-28. Statistical Analysis of the Effects of Ozone on the Carotenoid Content of White Fir Needles Pretreated with Acidic Fog[a]: July 1987

Treatment Variable	Needle Age Class	
	Young	Old
Air Quality[b] (AQ)		
CF	0.30 ± 0.05	0.35 ± 0.08
NF	0.32 ± 0.06	0.35 ± 0.08
Fog Pretreatment[c] (FP)		
pH 2.0	0.32 ± 0.04	0.35 ± 0.08
pH 3.0	0.32 ± 0.06	0.38 ± 0.08
pH 4.0	0.30 ± 0.06	0.34 ± 0.08
No Fog	0.31 ± 0.06	0.33 ± 0.07
AQ x FP		
CF/pH 2.0	0.31 ± 0.04	0.34 ± 0.07
NF/pH 2.0	0.33 ± 0.05	0.37 ± 0.09
CF/pH 3.0	0.31 ± 0.05	0.38 ± 0.08
NF/pH 3.0	0.33 ± 0.07	0.38 ± 0.09
CF/pH 4.0	0.27 ± 0.04	0.35 ± 0.09
NF/pH 4.0	0.32 ± 0.07	0.33 ± 0.08
CF/No Fog	0.30 ± 0.06	0.33 ± 0.07
NF/No Fog	0.32 ± 0.07	0.32 ± 0.07
ANOVA Effect[d]		
AQ	NS	NS
FP	NS	NS
AQ x FP	NS	NS
C.V. (%)[e]	14.8	22.0

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 32, 16, and 8 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-29. Statistical Analysis of the Effects of Ozone on the Carotenoid Content of White Fir Needles Pretreated with Acidic Fog[a]: August 1987

Treatment Variable	Needle Age Class	
	Young	Old
Air Quality[b] (AQ)		
CF	0.27 ± 0.06	0.30 ± 0.07
NF	0.27 ± 0.06	0.29 ± 0.07
Fog Pretreatment[c] (FP)		
pH 2.0	0.26 ± 0.06	0.29 ± 0.09
pH 3.0	0.27 ± 0.06	0.27 ± 0.03
pH 4.0	0.28 ± 0.04	0.30 ± 0.07
No Fog	0.29 ± 0.06	0.30 ± 0.07
AQ x FP		
CF/pH 2.0	0.25 ± 0.04	0.32 ± 0.09
NF/pH 2.0	0.27 ± 0.07	0.26 ± 0.09
CF/pH 3.0	0.27 ± 0.03	0.26 ± 0.03
NF/pH 3.0	0.26 ± 0.08	0.29 ± 0.03
CF/pH 4.0	0.28 ± 0.06	0.31 ± 0.05
NF/pH 4.0	0.27 ± 0.02	0.29 ± 0.09
CF/No Fog	0.29 ± 0.08	0.30 ± 0.09
NF/No Fog	0.29 ± 0.04	0.31 ± 0.04
ANOVA Effect[d]		
AQ	NS	NS
FP	NS	NS
AQ x FP	NS	NS
C.V. (%)[e]	14.1	18.3

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 32, 16, and 8 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-30. Statistical Analysis of the Effects of Ozone on the Carotenoid Content of White Fir Needles Pretreated with Acidic Fog[a]: September 1987

Treatment Variable	Needle Age Class	
	Young	Old
Air Quality[b] (AQ)		
CF	0.27 ± 0.07	0.31 ± 0.11
NF	0.25 ± 0.09	0.30 ± 0.08
Fog Pretreatment[c] (FP)		
pH 2.0	0.28 ± 0.07	0.31 ± 0.09
pH 3.0	0.24 ± 0.09	0.30 ± 0.12
pH 4.0	0.25 ± 0.08	0.31 ± 0.09
No Fog	0.28 ± 0.07	0.29 ± 0.09
AQ x FP		
CF/pH 2.0	0.29 ± 0.07	0.33 ± 0.10
NF/pH 2.0	0.26 ± 0.07	0.30 ± 0.07
CF/pH 3.0	0.26 ± 0.07	0.29 ± 0.16
NF/pH 3.0	0.22 ± 0.11	0.31 ± 0.09
CF/pH 4.0	0.25 ± 0.09	0.33 ± 0.09
NF/pH 4.0	0.25 ± 0.08	0.28 ± 0.09
CF/No Fog	0.28 ± 0.06	0.30 ± 0.11
NF/No Fog	0.28 ± 0.09	0.29 ± 0.07
ANOVA Effect[d]		
AQ	NS	NS
FP	NS	NS
AQ x FP	NS	NS
C.V. (%)[e]	33.6	35.6

[a]Mean ± one standard deviation in mg g^{-1} dry weight. Sample sizes of 32, 16, and 8 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p<0.05$.
[e]C.V. = coefficient of variation.

Table B-31. Statistical Analysis of the Effects of Ozone on the Starch Content of White Fir Pretreated with Acidic Fog[a]

Treatment Variable	White Fir
Air Quality[b] (AQ)	
CF	4.10 ± 1.63
NF	4.65 ± 2.19
Fog Pretreatment[c] (FP)	
pH 2.0	4.24 ± 1.71
pH 3.0	4.88 ± 1.94
pH 4.0	4.37 ± 2.46
No Fog	4.00 ± 1.76
AQ x FP	
CF/pH 2.0	3.22 ± 1.18
NF/pH 2.0	5.26 ± 1.62
CF/pH 3.0	4.30 ± 0.61
NF/pH 3.0	5.47 ± 2.73
CF/pH 4.0	4.15 ± 2.17
NF/pH 4.0	4.59 ± 3.06
CF/No Fog	4.73 ± 2.28
NF/No Fog	3.28 ± 0.78
ANOVA Effect[d]	
AQ	NS
FP	NS
AQ x FP	NS
C.V. (%)[e]	22.3

[a]Mean ± one standard deviation. Sample sizes of 16, 8, and 4 were used to examine the AQ, FP, and AQ x FP effects, respectively.
[b]CF = charcoal-filtered air; NF = nonfiltered air.
[c]Fog treatment applied in the Spring Fog Exposure Study.
[d]Results of the ANOVA; NS = not significant at $p < 0.05$.
[e]C.V. = coefficient of variation.

Table B-32. Comparison of Injury and Growth Responses of White Fir in Outside and Nonfiltered-No Fog Plots[a]

Parameter	Type of Plot: Outside	Type of Plot: Nonfiltered-No Fog	t-Test
Injury (% of total leaf area)			
June (Young Needles)	0.85 (1.45)	0.65 (1.44)	NS
July (Young Needles)	0.73 (2.49)	1.00 (1.82)	NS
August (Young Needles)	0.62 (2.15)	4.75 (13.69)	NS
June (Old Needles)	0.93 (1.52)	1.53 (1.87)	NS
July (Old Needles)	2.09 (4.62)	1.31 (1.44)	NS
August (Old Needles)	3.50 (7.53)	5.83 (9.60)	NS
Stem Height (mm)			
June	289 (53)	272 (55)	NS
July	291 (54)	273 (57)	NS
August	294 (55)	276 (56)	NS
September	294 (57)	275 (55)	NS
Stem Diameter (mm)			
June	9.2 (1.2)	9.7 (1.8)	NS
July	10.2 (1.5)	10.6 (1.9)	NS
August	10.3 (1.4)	10.7 (1.9)	NS
September	10.8 (1.4)	10.7 (2.0)	NS
Dry Biomass (g)			
Root	32.30 (9.49)	25.63 (9.39)	NS
Stem	13.17 (4.22)	13.70 (6.89)	NS
Needles	13.09 (4.60)	10.63 (4.88)	NS
Shoot	26.26 (8.30)	24.34 (11.31)	NS

[a]Mean ± one standard deviation. Values represent the average responses of plants grown in Outside (not grown in field chambers) and Nonfiltered-No Fog (exposed to ambient air and no fog pretreatment) plots. Sample sizes for each parameter are provided in previously presented tables.
[b]Results of the t-Test; NS = not significant at $p < 0.05$, * = significant at $p < 0.05$.

Table B-33. Comparison of Biochemical Responses of White Fir in Outside and Nonfiltered-No Fog Plots[a]

Parameter	Type of Plot: Outside		Type of Plot: Nonfiltered-No Fog		t-Test
Conductivity (μmhos cm^{-1} g^{-1} dry weight; NF-No fog data from Table 26)					
September (Young Needles)	1450	(56)	2211	(236)	*[b]
September (Old Needles)	1275	(111)	1702	(235)	*
K^+ Leakage (μg g^{-1} dry weight; Table 27)					
September (Young Needles)	8425	(414)	13134	(1014)	*
September (Old Needles)	9519	(363)	9743	(443)	NS
Total Chlorophyll (mg g^{-1} dry weight; Tables 28, 29, Appendices B-26, B-27)					
June (Young Needles)	1.44	(0.21)	1.73	(0.30)	*
July (Young Needles)	1.95	(0.44)	1.58	(0.23)	NS
August (Young Needles)	2.48	(0.79)	1.57	(0.16)	*
September (Young Needles)	2.94	(0.78)	2.35	(0.88)	NS
June (Old Needles)	4.38	(0.32)	3.83	(0.30)	NS
July (Old Needles)	4.61	(0.67)	3.91	(0.44)	*
August (Old Needles)	5.01	(0.61)	3.65	(0.44)	*
September (Old Needles)	4.77	(0.26)	3.48	(0.65)	*
Total Carotenoids (mg g^{-1} dry weight; Table 30, Appendices B-28 to B-30)					
June (Young Needles)	0.37	(0.04)	0.32	(0.07)	NS
July (Young Needles)	0.27	(0.06)	0.32	(0.07)	NS
August (Young Needles)	0.29	(0.06)	0.29	(0.04)	NS
September (Young Needles)	0.32	(0.03)	0.28	(0.09)	NS
June (Old Needles)	0.48	(0.10)	0.53	(0.06)	NS
July (Old Needles)	0.28	(0.10)	0.32	(0.07)	NS
August (Old Needles)	0.24	(0.05)	0.31	(0.04)	*
September (Old Needles)	0.40	(0.06)	0.29	(0.07)	*
Starch (mg g^{-1} dry weights; Appendix B-31)					
September (Old Needles)	5.09	(2.33)	3.28	(0.78)	NS

[a]Mean (± one standard deviation). Values represent the average responses of plants grown in Outside (not grown in field chambers) and Nonfiltered-No Fog (exposed to ambient air and no fog pretreatment) plots. Sample sizes for each parameter are provided in previously presented tables.
[b]Results of the t-Test; NS = not significant at $p<0.05$, * = significant at $p<0.05$.

APPENDIX C

Publications stemming from the ARB-sponsored research program on the effects of acidic fog on commercially-important herbaceous crops of California (Contract No. A5-087-32).

Experiments conducted in the summer and winter of 1986 have provided data for four peer-reviewed research publications to date. The manuscripts are:

(1) Takemoto, B.K., Olszyk, D.M., Johnson, A.G., and Parada, C.R. 1988. Yield responses of field-grown crops to acidic fog and ambient ozone. J. Environ. Qual. 17:192-197.

(2) Takemoto, B.K., Hutton, W.J., and Olszyk, D.M. 1988. Leaf drop, foliar pigment, and yield responses of alfalfa (*Medicago sativa* L.) exposed to simulated acidic fog and ambient ozone in the field. Environ. Pollut. 54:97-107.

(3) Takemoto, B.K., Bytnerowicz, A., and Olszyk, D.M. 1988. Depression of photosynthesis, growth, and yield in field-grown green pepper (*Capsicum annuum* L.) exposed to acidic fog and ambient ozone. Plant Physiol. 88:477-482.

(4) Takemoto, B.K. Bytnerowicz, A, and Olszyk, D.M. 1989. Physiological responses of field-grown strawberry (*Fragaria x Ananassa* Duch.) exposed to acidic fog and ambient ozone. Accepted by Environmental and Experimental Botany.

APPENDIX D

Outline of the sources of variation in the statistical design of the ANOVA tests conducted on the data from the Spring Fog and Summer Ozone Exposure Studies.

The results from the acidic fog exposures were analyzed utilizing the following ANOVA scheme:

Block (B)	(Variation due to treatment blocks)
Fog Chemistry (F)	(Variation due to fog chemistry treatment
B x F	(Variation due to B x F interaction)
Sampling Error	(Plant-to-plant variability)

For the O_3 exposure study:

Block (B)	(Variation due to treatment blocks)
Fog Pretreatment (F)	(Variation due to fog pretreatment)
B(F)	(Variation due to B x F interaction)
Air Quality (A)	(Variation due to air quality effects)
A x F	(Variation due to A x F interaction)
A x B x F	(Variation due to A on B x F)
Sampling Error	(Plant-to-plant variability)

With the exception of the pooled gas exchange data, the aforementioned formats were used. A sampling date component was included for the pooled gas exchange data to account for the variation attributable to multiple measurement periods.

00000870
ASSET