APPENDICES

Appendix 1. Fuel layers

Figure 18. Example of the elevated dead fuel layer collected from branches.

Figure 19. Example of the surface litter layer collected on the ground. Live material was discarded.

Figure 20. Examples of the loose duff layer collected from below the surface litter.

Figure 21. Examples of the compact duff layer collected from below the loose duff layer.

Figure 22. Example of soil type (sand) collected from below the compact duff layer.

Appendix 2. Fuel moisture sampling sheet

Date:	
Sampled by:	
Location:	
Sample Start (hh:mm)	Sample End (hh:mm)

Oven In Date		Time In oven	
Oven Out Date		Time Out of oven	

Elevated needles (dead)

Container Number	Wet Wgt.	Dry Wgt.

Surface layer (dead needle litter)

Container Number	Wet Wgt.	Dry Wgt.

Loose Duff

Container Number	Wet Wgt.	Dry Wgt.

Compact Duff

Container Number	Wet Wgt.	Dry Wgt.

Mineral soil (0-10 cm deep)

Container Number	Wet Wgt.	Dry Wgt.

Psychrometer readings (NB – must run for at least 5 minutes, change the wet wick 1-2 times per week)

Time	Wet Bulb (°C)	Dry Bulb (°C)	Relative Humidity (%)

1. Elevated fuel: fine, dead fuel suspended in shrubs, more than 30 cm above the ground. Includes leaves and small (< 5 mm diameter) twigs. Collect dead fuel only.
2. Surface fuel: the top 0 – 2 cm of the litter layer. Includes leaves, bark (if present) and small (< 5 mm diameter) twigs from all species. Collect dead fuel only, discard any green material.
3. Loose Duff: loosely compacted organic layers of moderate depth (2-7cm).This layer is in early stages of decomposition (leaf and twig fragments are visible).
4. Compact Duff: deep, compact organic layer in advanced state of decay down to the mineral soil layer (8-18cm depth approx). Leaf and twig fragments are still visible, but are tightly bounded by fungal mycelia. Includes leaves, bark, small (< 5 mm diameter) twigs, and decomposed material from all species.
5. Mineral soil: no signs of leaf or twig fragments visible.

*Weights are with the container lid on.

Mineral soil (10-20 cm deep)		
Container Number	**Wet Wgt.**	**Dry Wgt.**

Container Number	**Wet Wgt.**	**Dry Wgt.**

Container Number	**Wet Wgt.**	**Dry Wgt.**

Container Number	**Wet Wgt.**	**Dry Wgt.**

Container Number	**Wet Wgt.**	**Dry Wgt.**

Container Number	**Wet Wgt.**	**Dry Wgt.**

Appendix 3. Fire weather conditions

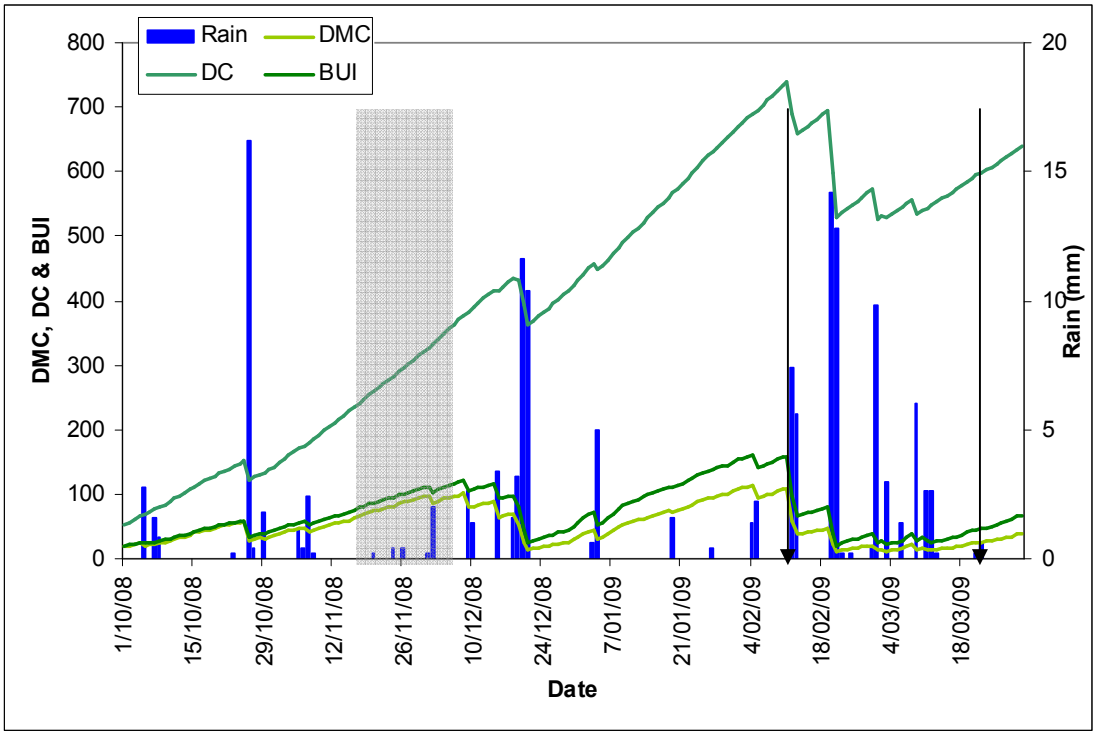


Figure 23. Fire weather conditions (DMC, DC and BUI) collected from Bottle Lake RAWS during daily (shaded area) and hourly (arrows) sampling, 1 November 2008 to 31 March 2009. (Source: NRFA).

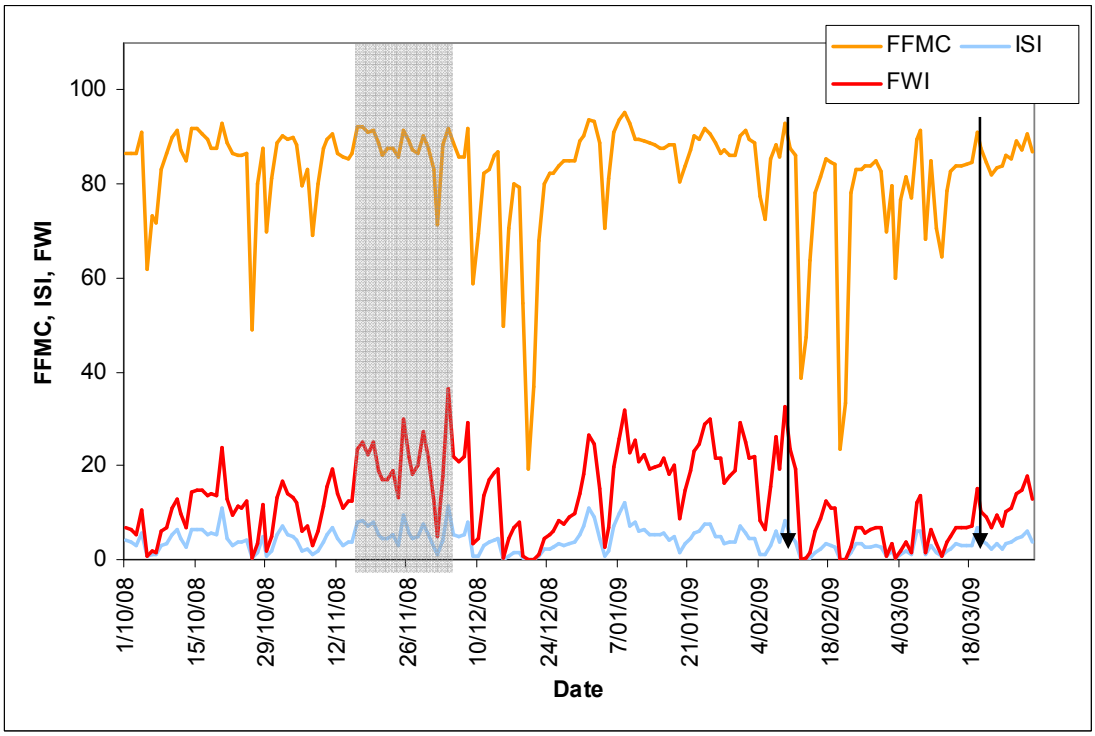


Figure 24. Fire weather conditions (FFMC, ISI and FWI) collected from Bottle Lake RAWS during daily (shaded area) and hourly (arrows) sampling, 1 November 2008 to 31 March 2009. (Source: NRFA).

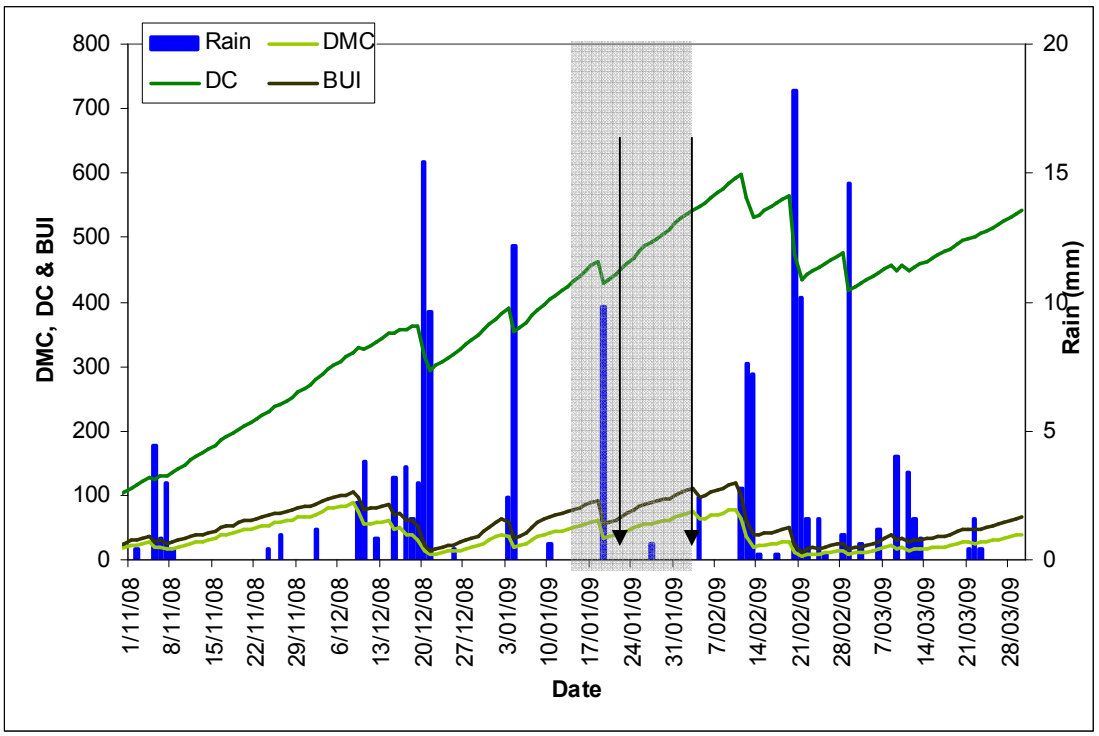


Figure 25. Fire weather conditions (FFMC, ISI and FWI) collected from Christchurch Aero RAWS during daily (shaded area) and hourly (arrows) sampling, 1 November 2008 to 31 March 2009. (Source: NRFA).

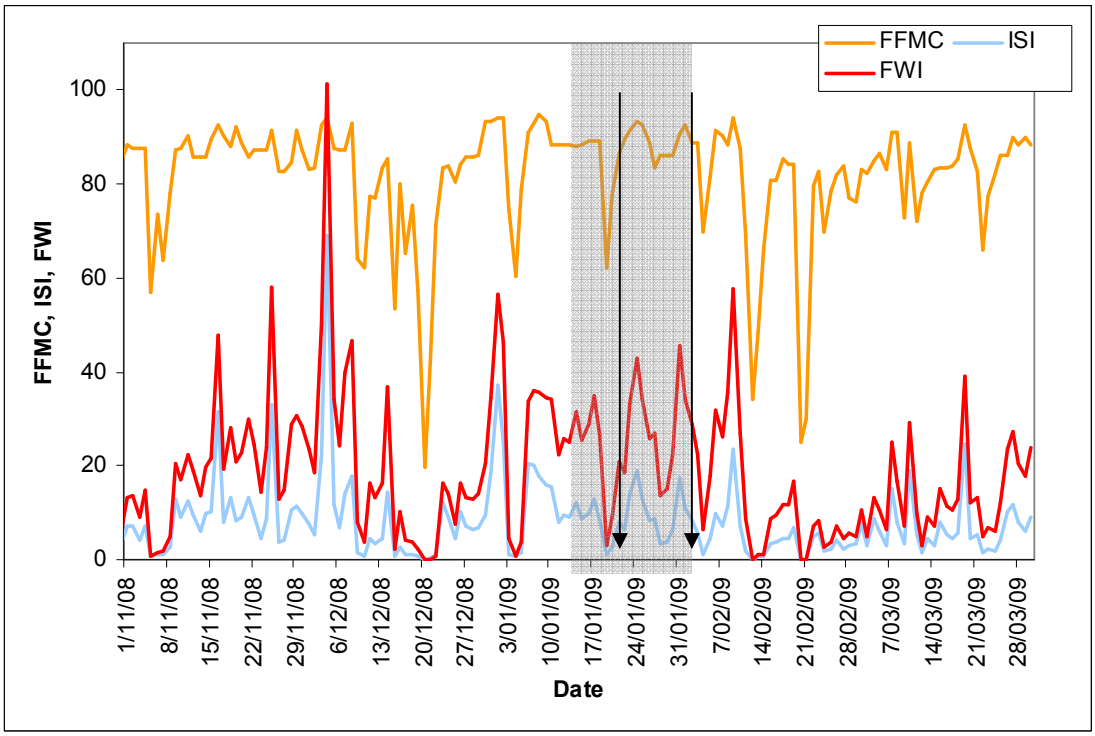


Figure 26. Fire weather conditions (FFMC, ISI and FWI) collected from Christchurch Aero RAWS during daily (shaded area) and hourly (arrows) sampling, 1 November 2008 to 31 March 2009. (Source: NRFA).

Appendix 4. Daily data

4.1 Weather conditions during and before sampling

Bottle Lake Forest

One week before sampling commenced, the Bottle Lake site was slightly warmer (21.4ºC) and less humid (51%) compared to the conditions during sampling (Table 11). The FWI System codes and indices (except FFMC) were generally lower a week before sampling. No significant rain (greater than 0.6 mm) fell during the week before. Four weeks before sampling, the site was generally cooler (18.2ºC) and less humid (50.6%) and all FWI System codes and indices were lower. Significant rain fell 11 and 23 days before sampling (2.4 mm and 16.2 mm respectively).

Table 11. Summary of daily fire weather observations (Source: Bottle Lake RAWS, NRFA).

Bottle Lake Forest	Average	Median	Min	Max
During sampling				
Temperature (ºC)	20.2	19.6	16.2	26.9
Relative humidity (%)	53.2	55.0	30.0	83.0
Rainfall (mm)	0.2	0	0	2.0
FFMC	87.4	87.8	71.5	91.7
DMC	85.8	87.4	69.2	96.7
DC	303.0	301.4	247.6	362.8
ISI	5.6	5.2	1.0	11.4
BUI	100.4	102.4	81.5	116.1
FWI	20.4	19.9	5.1	36.2
1 week before sampling				
Temperature (ºC)	21.4	20.7	17.2	27.9
Relative humidity (%)	51.0	56.0	27.0	69.0
Rainfall (mm)	0	0	0	0
FFMC	88.5	86.4	85.5	92.2
DMC	58.6	57.1	53.3	66.8
DC	223.0	222.1	205.3	242.0
ISI	5.5	4.4	3.1	8.5
BUI	70.8	69.5	64.7	79.1
FWI	16.9	14.0	10.9	25.1
4 weeks before sampling				
Temperature (ºC)	18.2	17.5	11.3	27.9
Relative humidity (%)	50.6	53.0	27.0	77.0
Rainfall (mm)	0.8	0	0	16.2
FFMC	84.2	86.4	48.9	92.2
DMC	46.8	47.1	26.4	66.8
DC	171.6	164.0	120.9	242.0
ISI	3.9	3.8	0.3	8.5
BUI	55.3	55.0	34.2	79.1
FWI	11.3	12.0	0.3	25.1

McLeans Island Forest

One week before sampling, the McLeans Island site was slightly cooler (20.1ºC) and less humid (49.4%) compared to conditions during sampling (Table 5). The FFMC, ISI and FWI was higher, whereas the DMC, DC and BUI was lower a week before sampling. Six days before sampling 0.6 mm of rain fell. Four weeks before sampling, the site had similar temperature (21.1ºC), was more humid (51.2%) and wetter (a total of 43.6 mm rain). All FWI System codes and indices (except ISI) were lower than those during sampling. Significant rain fell 12 and 27 days before sampling (12.2 mm and 15.4 mm respectively).

Table 12. Summary of daily fire weather observations (Source: Christchurch Aero RAWS, NRFA).

McLeans Island	Average	Median	Min	Max
During sampling				
Temperature (ºC)	21.8	21.0	13	30
Relative humidity (%)	50.5	48.0	25.0	77.0
Rainfall (mm)	0.6	0	0	9.8
FFMC	85.9	88.7	62.1	93.4
DMC	55.8	58.4	33.4	73.6
DC	488.7	485.8	429.1	554.8
ISI	8.3	8.2	1.0	19.0
BUI	86.5	88.5	55.9	109.9
FWI	24.4	25.9	3.1	45.5
1 week before sampling				
Temperature (ºC)	20.1	20.0	17.0	25.0
Relative humidity (%)	49.4	51.0	33.0	55.0
Rainfall (mm)	0.1	0	0	0.6
FFMC	89.0	88.4	88.1	93.2
DMC	45.6	45.5	39.5	52.3
DC	417.1	416.7	396.0	439.1
ISI	11.2	9.4	8.1	16.0
BUI	71.6	71.5	63.2	80.6
FWI	28.5	25.6	22.4	34.4
4 weeks before sampling				
Temperature (ºC)	21.1	20	11	33
Relative humidity (%)	51.2	53.0	21.0	94.0
Rainfall (mm)	1.6	0	0	15.4
FFMC	81.1	87.1	19.9	94.7
DMC	28.0	28.0	7.3	52.3
DC	364.4	364.7	293.9	439.1
ISI	10.4	9.1	0.0	37.4
BUI	46.1	47.0	13.7	80.6
FWI	20.3	18.3	0.0	56.4

4.2 Daily fire weather

Table 13. Daily fire weather conditions and predicted moisture contents from the Bottle Lake RAWS: 18 November to 6 December 2008 (Source: NRFA).

	Fire weather readings						Moisture content predicted from FWI System fuel moisture codes			
Date	**Temp (ºC)**	**RH (%)**	**Rain (mm)**	**FFMC**	**DMC**	**DC**	**FFMC (FF-scale)**	**FFMC (Fx-scale)**	**DMC**	**DC**
18/11/2008	17.5	40	0	90.91	69.08	247.59	9.87	3.18	77.07	215.40
19/11/2008	23	31	0	91.36	72.60	254.13	9.41	3.03	72.62	211.90
20/11/2008	16.3	53	**0.2**	88.86	74.34	259.47	12.05	3.91	70.56	209.09
21/11/2008	16.7	67	0	86.25	75.58	264.88	14.90	4.87	69.13	206.29
22/11/2008	21	48	0	87.52	78.02	271.06	13.50	4.40	66.45	203.12
23/11/2008	22.6	59	0	87.57	80.08	277.54	13.44	4.38	64.29	199.86
24/11/2008	19.6	71	**0.4**	85.74	81.36	283.47	15.47	5.07	63.01	196.92
25/11/2008	26.9	30	0	91.52	85.51	290.71	9.24	2.97	59.09	193.38
26/11/2008	16.3	52	**0.4**	89.00	87.29	296.05	11.90	3.86	57.52	190.82
27/11/2008	16.3	59	0	87.41	88.80	301.39	13.62	4.44	56.24	188.29
28/11/2008	19.9	65	0	86.55	90.36	307.38	14.56	4.76	54.96	185.49
29/11/2008	25.7	37	0	90.13	93.94	314.41	10.70	3.46	52.19	182.26
30/11/2008	17.6	59	0	87.75	95.57	319.98	13.24	4.31	51.01	179.74
1/12/2008	16.2	83	**0.2**	83.21	96.22	326.30	18.35	6.06	50.54	176.92
2/12/2008	19.8	72	**2**	71.49	84.79	333.27	33.16	11.44	59.75	173.87
3/12/2008	26.4	30	0	88.40	89.09	341.42	12.54	4.07	56.00	170.36
4/12/2008	26	30	0	91.73	93.33	349.51	9.02	2.90	52.65	166.95
5/12/2008	18.2	55	0	88.81	95.27	356.19	12.10	3.92	51.22	164.19
6/12/2008	17.7	70	0	85.81	96.53	362.78	15.39	5.04	50.33	161.50
Average	20.19	53.21	0.17	87.37	85.67	303.03	13.81	4.53	59.72	188.23
Median	19.60	55.00	0.00	87.75	87.29	301.39	13.24	4.31	57.52	188.29
Min	16.20	30.00	0.00	71.49	69.08	247.59	9.02	2.90	50.33	161.50
Max	26.90	83.00	2.00	91.73	96.53	362.78	33.16	11.44	77.07	215.40
Sum			3.2							

Table 14. Daily fire weather conditions and predicted moisture contents from the Christchurch Aero RAWS: 16 January to 5 February 2009 (Source: NRFA).

	Fire weather readings						Moisture content predicted from FWI System fuel moisture codes			
Date	**Temp (ºC)**	**RH (%)**	**Rain (mm)**	**FFMC**	**DMC**	**DC**	**FFMC (FF-scale)**	**FFMC (Fx-scale)**	**DMC**	**DC**
16/01/2009	26	45	0	89.15	55.53	447.51	11.74	3.80	97.96	130.67
17/01/2009	24	47	0	89.20	58.43	455.53	11.68	3.79	92.93	128.08
18/01/2009	21	46	0	89.25	61.03	463.02	11.63	3.77	88.69	125.70
19/01/2009	18	53	**9.8**	62.06	33.42	429.12	47.15	16.99	149.71	136.82
20/01/2009	16	62	0	77.94	34.84	435.71	24.69	8.31	145.55	134.58
21/01/2009	22	48	0	86.43	37.45	443.37	14.70	4.80	138.21	132.03
22/01/2009	26	40	0	89.61	40.99	451.76	11.25	3.64	128.95	129.29
23/01/2009	27	33	0	91.52	45.09	460.32	9.24	2.97	119.14	126.55
24/01/2009	28	25	0	93.40	49.85	469.06	7.32	2.34	108.86	123.82
25/01/2009	28	39	0	92.43	53.71	477.81	8.31	2.67	101.29	121.14
26/01/2009	24	59	0	88.65	55.96	485.83	12.27	3.98	97.20	118.73
27/01/2009	13	77	**0.6**	83.51	56.66	491.88	18.00	5.94	95.95	116.95
28/01/2009	18	48	0	86.25	58.82	498.82	14.89	4.87	92.26	114.94
29/01/2009	19	67	0	85.94	60.27	505.94	15.24	4.99	89.90	112.91
30/01/2009	19	66	0	85.99	61.76	513.07	15.18	4.97	87.54	110.92
31/01/2009	28	37	0	90.71	65.75	521.81	10.08	3.25	81.61	108.52
1/02/2009	30	30	0	92.64	70.08	530.22	8.09	2.59	75.77	106.26
2/02/2009	15	54	0	88.72	71.55	535.92	12.20	3.96	73.91	104.76
3/02/2009	19	48	0	88.76	73.63	542.34	12.15	3.94	71.39	103.09
4/02/2009	17	75	**2.4**	69.82	62.52	548.83	35.49	12.33	86.37	101.54
5/02/2009	19	62	0	81.53	64.04	554.83	20.32	6.75	84.09	99.92
Average	21.76	50.52	0.61	85.88	55.78	488.68	15.79	5.27	100.35	118.44
Median	21.00	48.00	0.00	88.72	58.43	485.83	12.20	3.96	92.93	118.73
Min	13.00	25.00	0.00	62.06	33.42	429.12	7.32	2.34	71.39	99.92
Max	30.00	77.00	9.80	93.40	73.63	554.83	47.15	16.99	149.71	136.82
Sum			12.8							

4.3 Actual moisture content

Table 15. Daily actual moisture content and weather readings under the forest canopy from Bottle Lake Forest: 18 November to 6 December 2008.

	Average Fuel Moisture Content						Weather (averages)		
Date	Elevated	Surface	Loose	Compact	Soil 0-10 cm	Soil 10-20 cm	RH (%)	Temp (ºC) (wet bulb)	Temp (ºC) (dry bulb)
18/11/2008	17.23	15.56	47.73	27.93	6.45	2.55	11.74	3.80	97.96
19/11/2008	12.64	12.77	35.03	42.13	4.46	2.17	11.68	3.79	92.93
20/11/2008	15.74	15.75	26.77	13.84	3.48	2.41	11.63	3.77	88.69
21/11/2008	17.96	18.23	23.90	17.80	3.11	1.72	47.15	16.99	149.71
22/11/2008	13.84	16.00	30.52	25.49	3.23	2.00	24.69	8.31	145.55
23/11/2008	19.56	17.83	24.81	32.09	5.32	4.03	14.70	4.80	138.21
24/11/2008	19.22	20.86	27.44	22.40	3.38	2.48	11.25	3.64	128.95
25/11/2008	11.62	12.69	22.42	17.89	4.95	2.85	9.24	2.97	119.14
26/11/2008	16.36	16.32	19.17	49.97	5.50	3.35	7.32	2.34	108.86
27/11/2008	19.74	15.53	22.43	18.91	5.24	2.93	8.31	2.67	101.29
28/11/2008	19.54	17.21	22.68	23.68	2.85	1.76	12.27	3.98	97.20
29/11/2008	14.96	14.98	23.40	21.51	5.79	3.90	18.00	5.94	95.95
30/11/2008	18.61	23.60	19.89	11.59	2.12	1.51	14.89	4.87	92.26
1/12/2008	23.45	23.60	26.63	18.58	3.51	2.36	15.24	4.99	89.90
2/12/2008	20.96	58.73	98.99	61.61	5.89	2.37	15.18	4.97	87.54
3/12/2008	12.68	17.43	36.10	15.86	3.79	1.96	10.08	3.25	81.61
4/12/2008	10.82	13.07	27.76	18.18	4.27	2.62	8.09	2.59	75.77
5/12/2008	17.69	14.97	19.20	29.66	2.76	2.18	12.20	3.96	73.91
6/12/2008	18.73	17.01	23.41	21.39	3.19	2.54	12.15	3.94	71.39
Average	16.91	19.06	30.44	25.82	4.17	2.51	61.27	13.23	17.85
Median	17.69	16.32	24.81	21.51	3.79	2.41	60.90	14.00	16.30
Min	10.82	12.69	19.17	11.59	2.12	1.51	33.80	9.20	12.50
Max	23.45	58.73	98.99	61.61	6.45	4.03	82.50	17.00	24.40

Table 16. Daily actual moisture content and weather readings under the forest canopy from McLeans Island Forest: 16 January to 5 February 2009.

	Average Fuel Moisture Content						Weather (averages)		
Date	Elevated	Surface	Loose	Compact	Soil 0-10 cm	Soil 10-20 cm	RH (%)	Temp (ºC) (wet bulb)	Temp (ºC) (dry bulb)
16/01/2009	12.25	13.97		7.91	5.27	4.82	46.7	19.4	27.4
17/01/2009	11.31	11.31		10.41	4.35	4.06	33.1	0.331	24.4
18/01/2009	16.35	24.76		49.03	8.38	4.36			
19/01/2009									
20/01/2009	15.50	23.28		63.25	8.49	6.65	61.35	11.2	15.2
21/01/2009	13.98	16.12		26.52	6.76	7.69	54.2	15.2	20.9
22/01/2009	11.86	14.69		23.31	7.09	5.17	39.25	16.9	25.9
23/01/2009	8.33	13.67	20.60	17.78	4.79	3.30	30.9	16.1	26.9
24/01/2009	12.69	12.75	13.78	13.32	2.53	1.90	54.75	17.3	23.3
25/01/2009	11.05	11.96	13.74	20.40	3.00	2.35	37.2	17	26.5
26/01/2009	15.19	11.54	15.62	10.37	3.26	2.59	63.2	18	22.7
27/01/2009	20.30	54.13	128.19	49.48	2.37	2.13	76.45	10.7	12.9
28/01/2009	15.03	19.31	55.87	17.95	1.89	2.23	58.45	12.6	17.2
29/01/2009	13.64	18.74	23.88	36.15	4.14	8.06	45.8	14.5	21.5
30/01/2009	18.69	18.92	25.08	28.19	4.06	2.98	74.95	14.7	17.4
31/01/2009	12.82	14.39	15.51	12.85	3.29	3.30	49.4	17.9	25
1/02/2009	13.07	13.43	14.99	15.03	2.51	1.97	49.55	12.05	17.85
2/02/2009	16.22	14.49	17.80	14.56	3.13	2.34	67.1	10.4	13.6
3/02/2009	12.58	12.88	14.03	10.46	3.08	2.53	44.75	14.1	21.2
4/02/2009	19.59	35.08	111.37	63.76	2.95	2.41	77	13.7	16.1
5/02/2009	16.65	20.40	68.37	32.82	2.04	1.92	58.05	14.7	19.7
Average	14.36	18.79	38.49	26.18	4.17	3.64	53.80	14.04	20.82
Median	13.81	14.59	19.20	19.17	3.28	2.78	54.20	14.70	21.20
Min	8.33	11.31	13.74	7.91	1.89	1.90	30.90	0.33	12.90
Max	20.30	54.13	128.19	63.76	8.49	8.06	77.00	19.40	27.40

4.4 Actual (sampled) fuel moisture content time-series

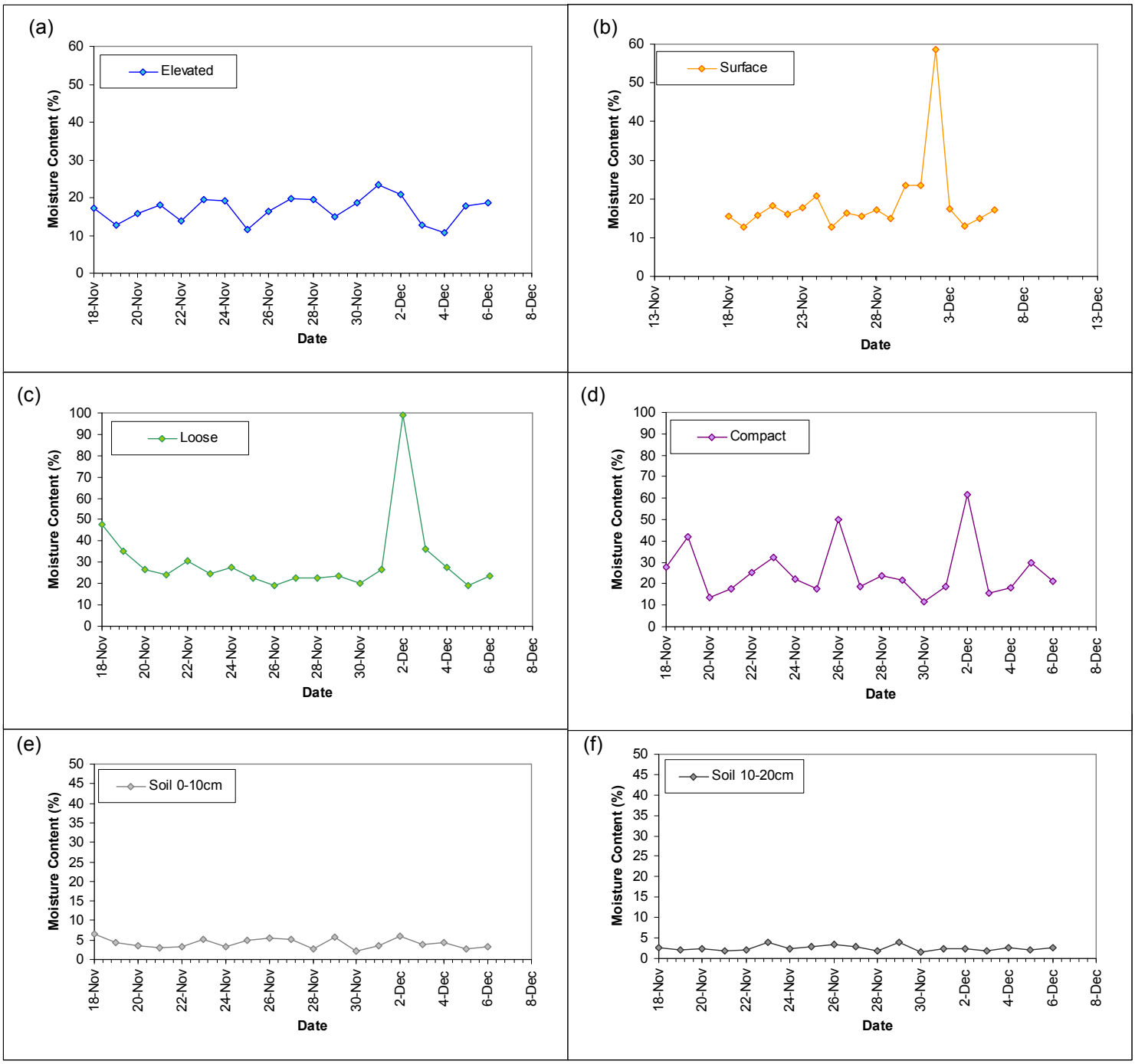


Figure 27. Daily moisture samples collected at Bottle Lake Forest from 18 November to 6 December 2008: (a) Elevated, (b) Surface, (e) Loose duff, (d) Compact duff, (e) Soil (0-10 cm) & (f) Soil (10-20 cm) layers.

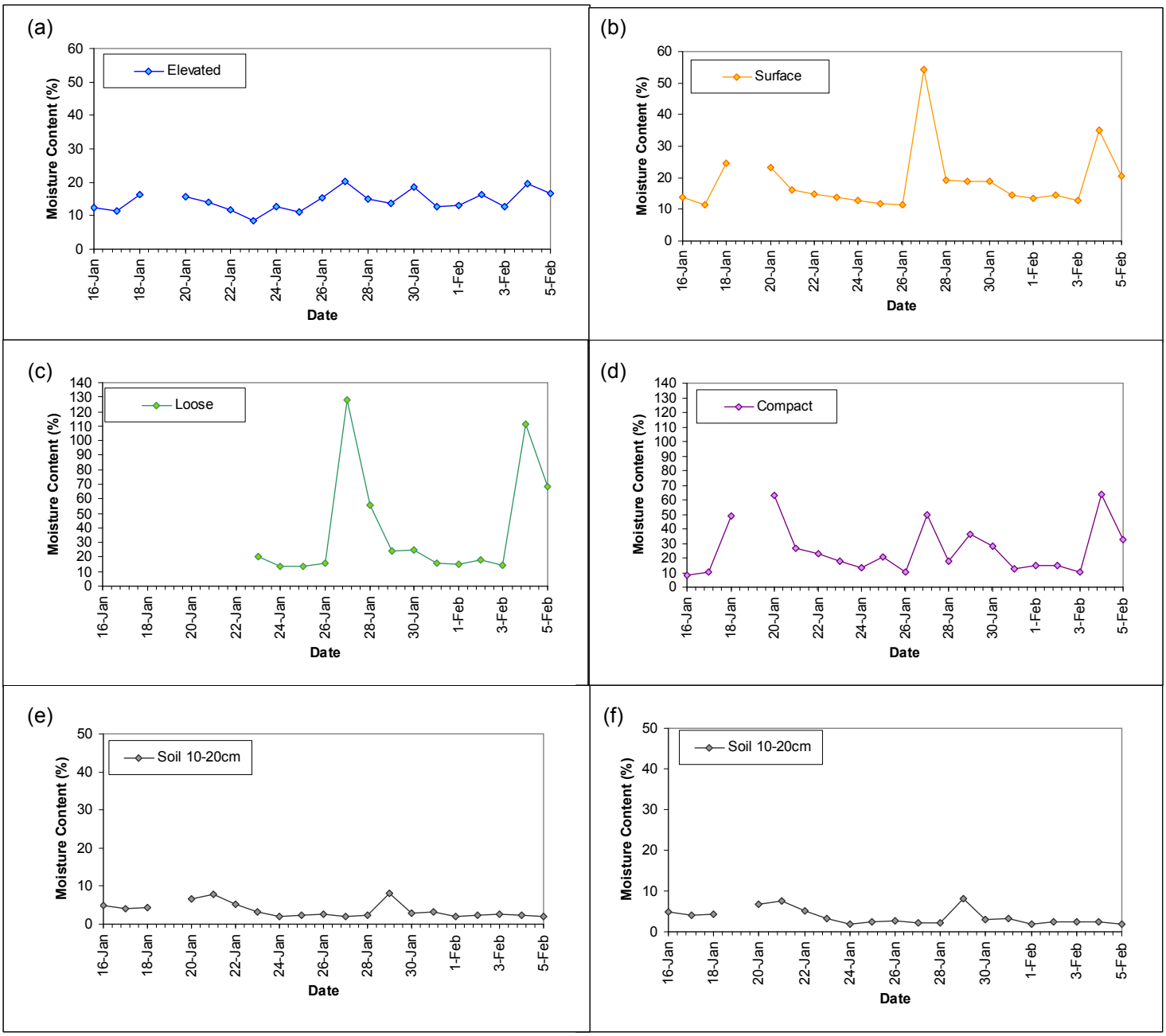


Figure 28. Daily moisture samples collected at McLeans Island Forest from 16 January to 5 February 2009: (a) Elevated, (b) Surface, (e) Loose duff, (d) Compact duff, (e) Soil (0-10 cm) & (f) Soil (10-20 cm) layers.

4.5 Time-series of actual and predicted fuel moisture content using weather observations at the time of sampling (1600 NZST).

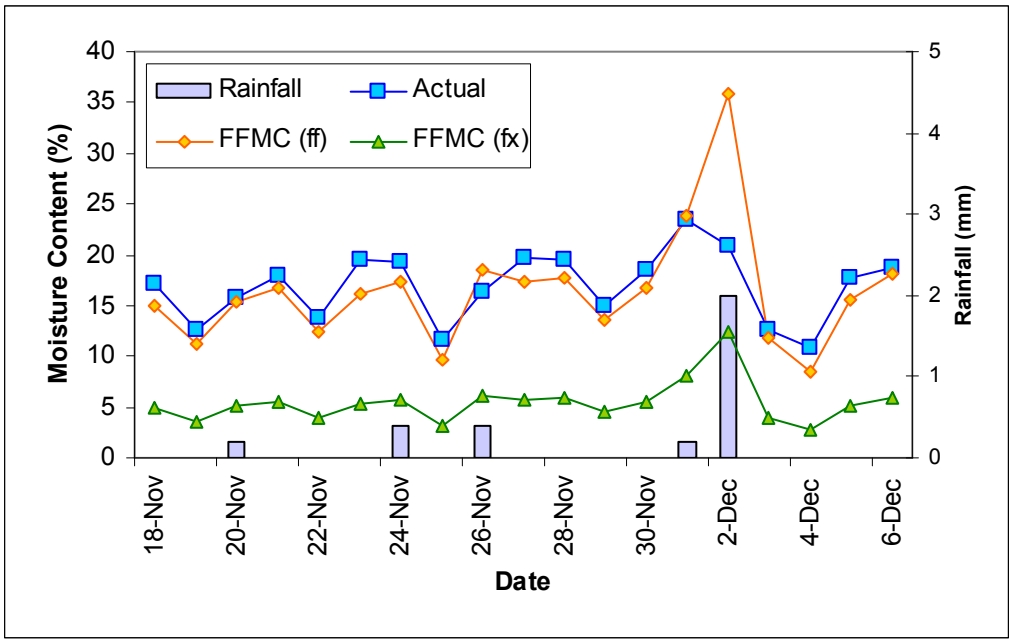


Figure 29. Time-series of actual and predicted moisture content for the **elevated layer** at Bottle Lake Forest from 18 November to 6 December 2008.

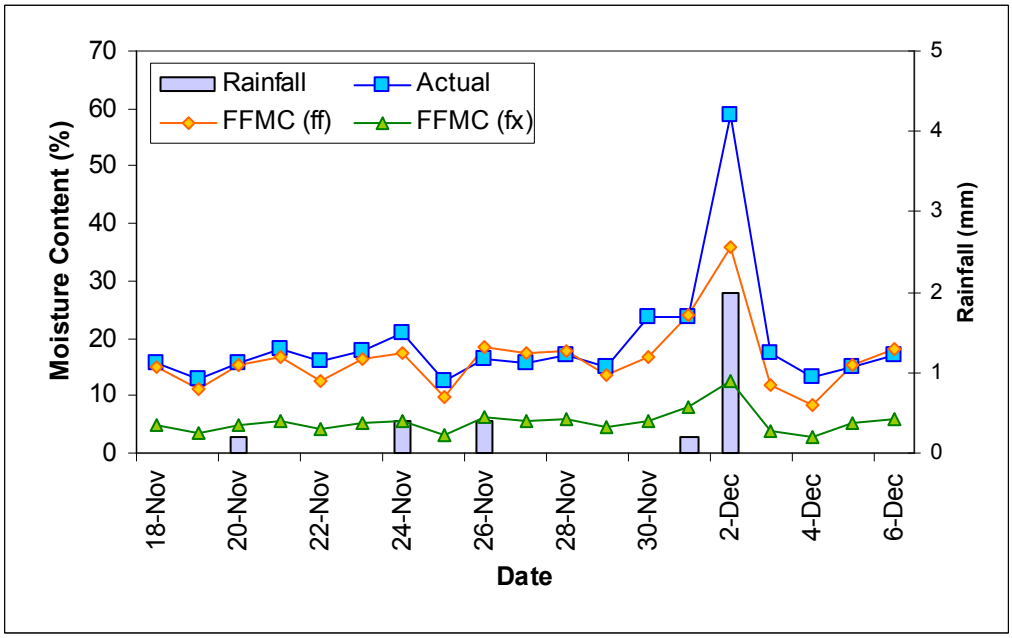


Figure 30. Time-series of actual and predicted moisture content for the **surface layer** at Bottle Lake Forest from 18 November to 6 December 2008.

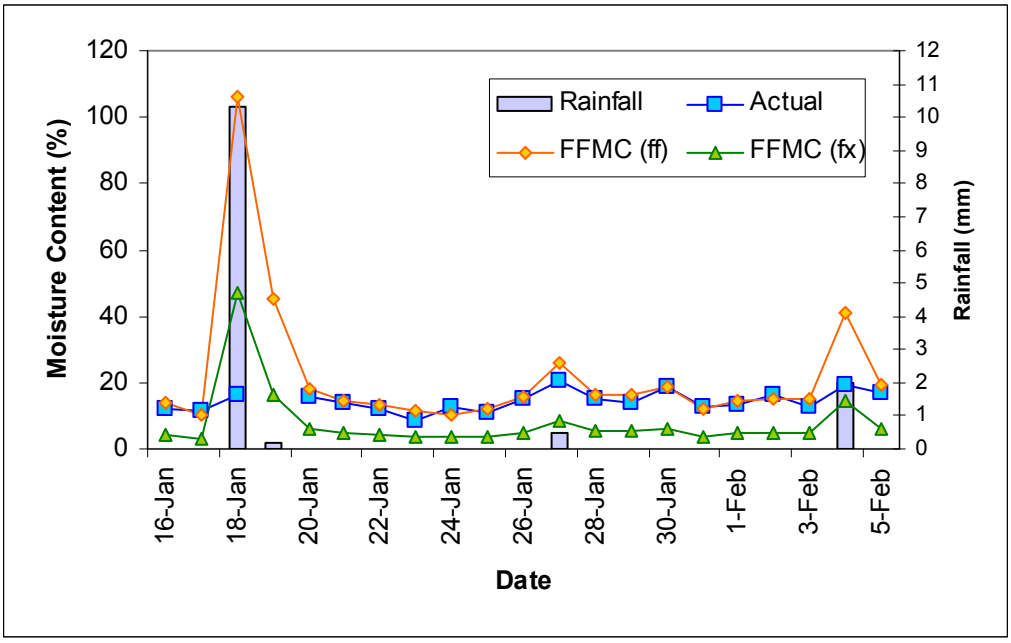


Figure 31. Time-series of actual and predicted moisture content for the **elevated layer** at McLeans Island Forest from 16 January to 5 February 2009.

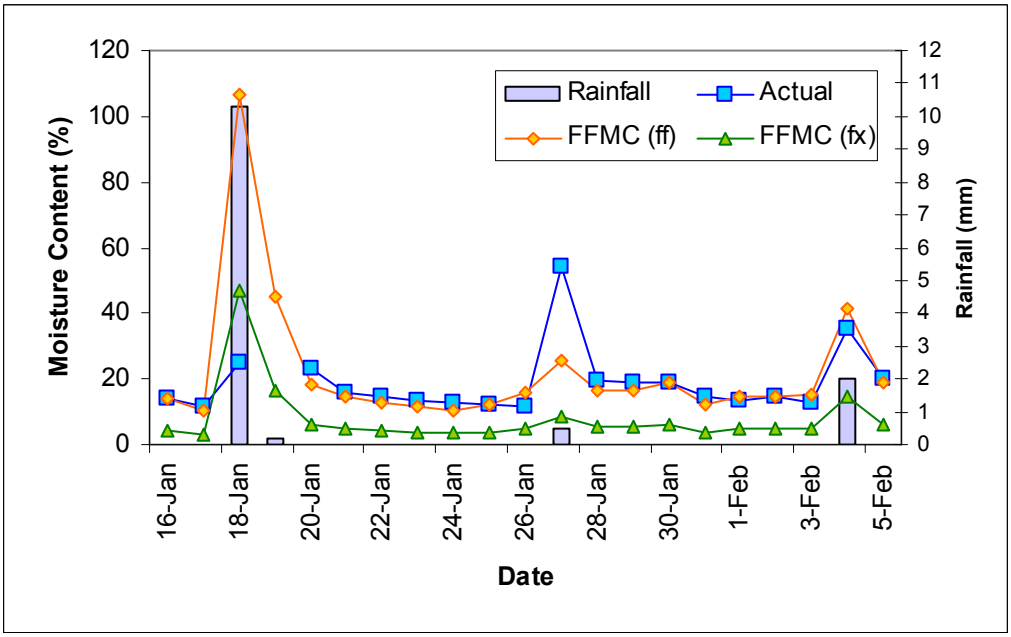


Figure 32. Time-series of actual and predicted moisture content for the **surface layer** at McLeans Island Forest from 16 January to 5 February 2009.

4.6 Actual versus predicted fuel moisture content using weather observations at the time of sampling (1600 NZST).

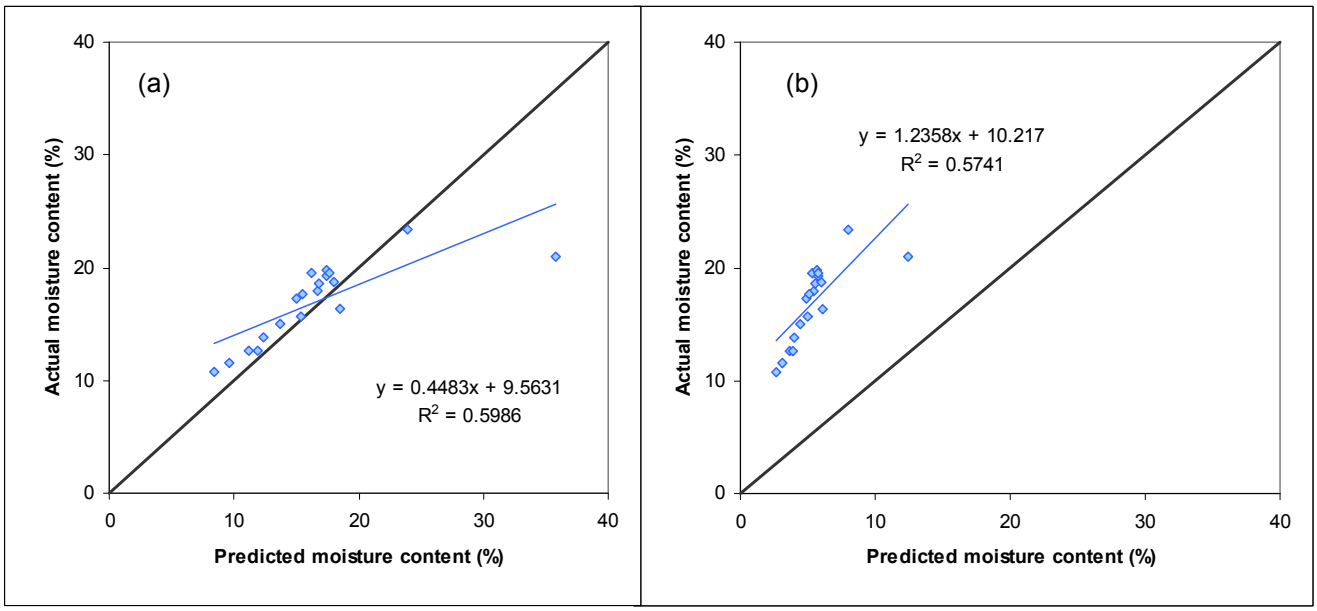


Figure 33. Actual versus predicted **elevated fuel** moisture content using the 1600 hour FFMC from Bottle Lake RAWS: (a) FF-scale, (b) FX-scale (Source: NRFA, n = 19).

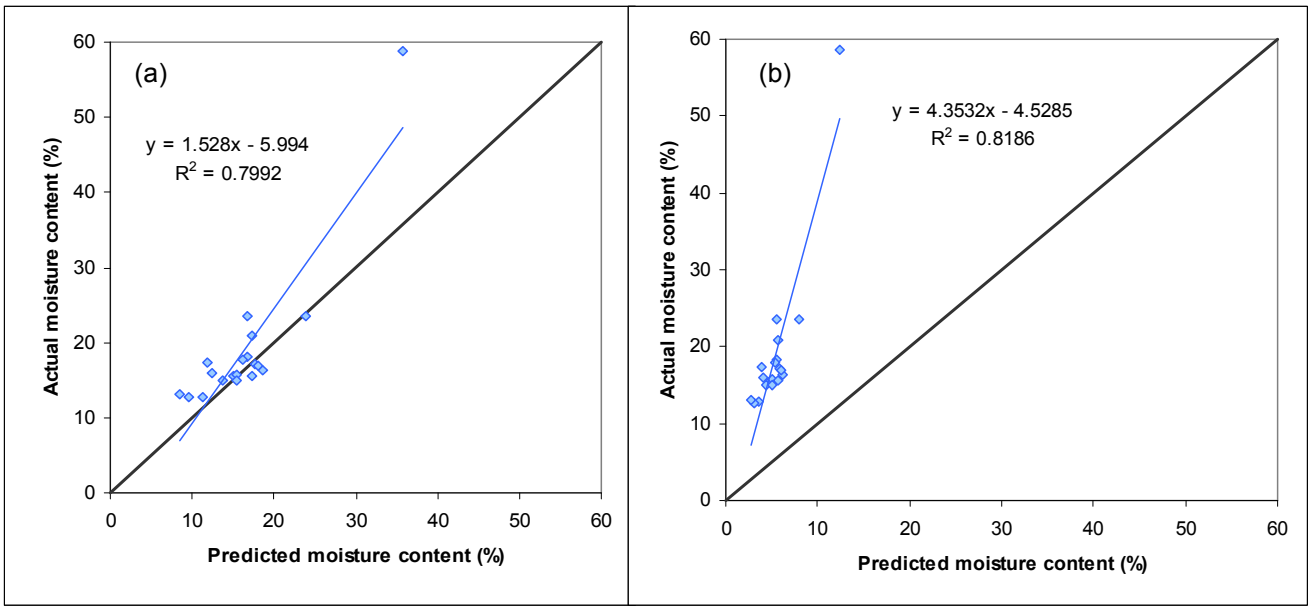


Figure 34. Actual versus predicted **surface fuel** moisture content using the 1600 hour FFMC from Bottle Lake RAWS: (a) FF-scale, (b) FX-scale (Source: NRFA, n = 19).

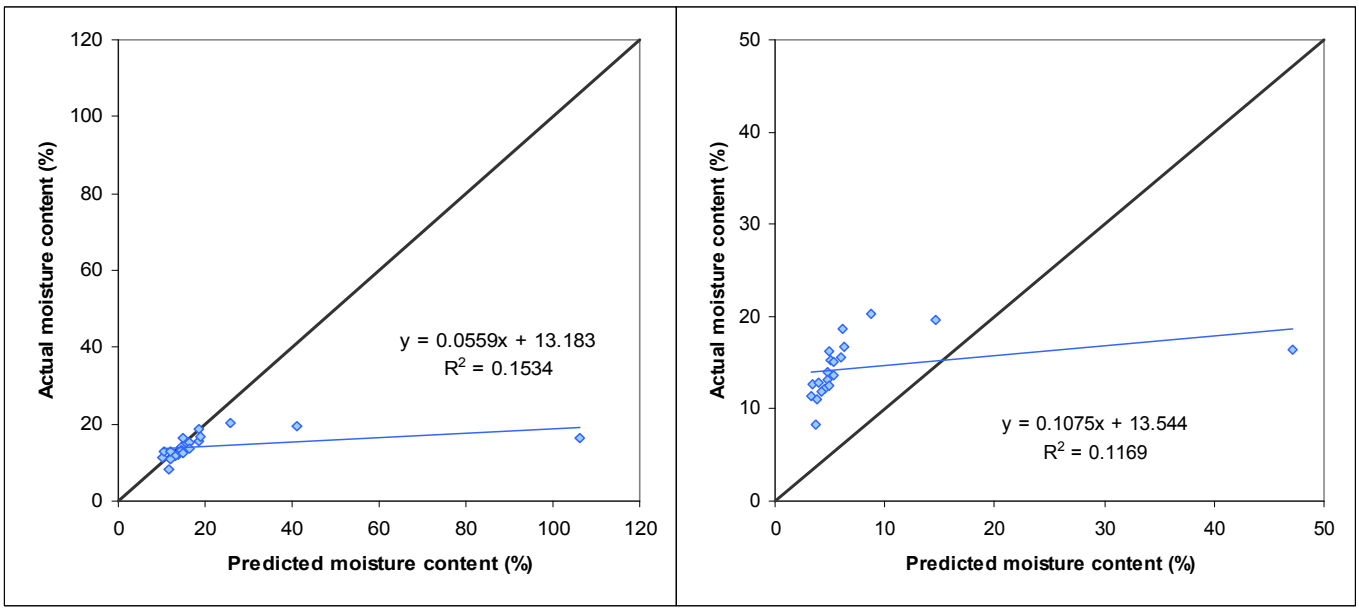


Figure 35. Actual versus predicted **elevated fuel** moisture content using the 1600 hour FFMC from Christchurch Aero: (a) FF-scale, (b) FX-scale (Source: NIWA, n = 20).

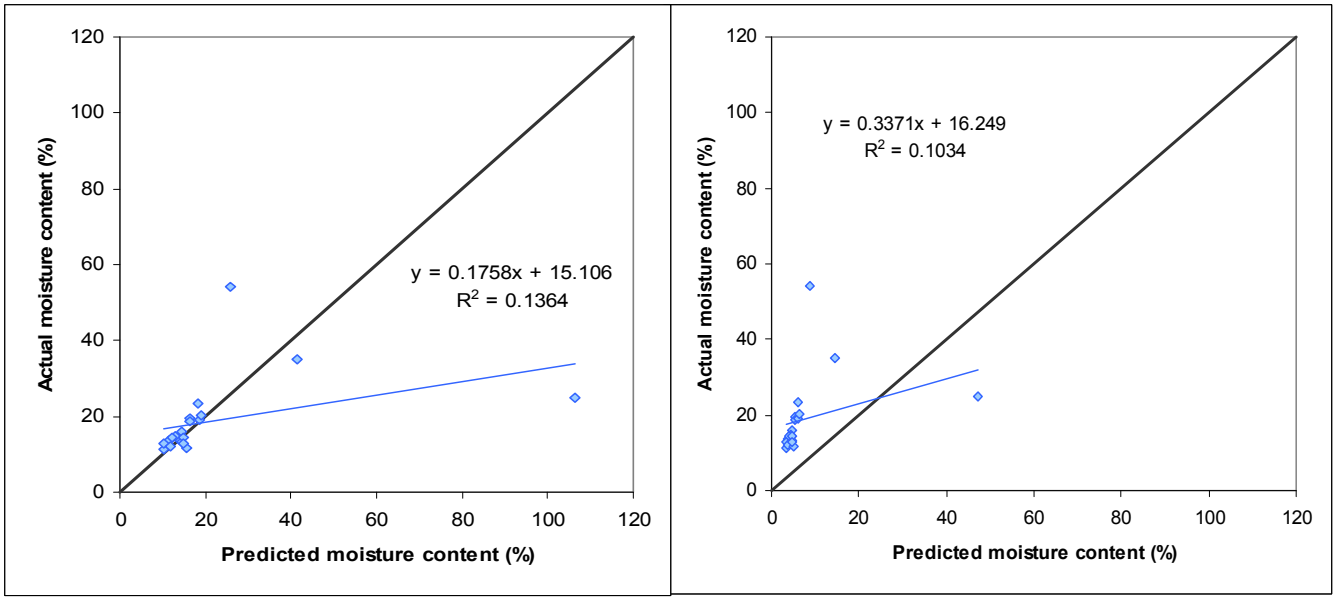


Figure 36. Actual versus predicted **surface fuel** moisture content using the 1600 hour FFMC from Christchurch Aero: (a) FF-scale, (b) FX-scale (Source: NIWA, n = 20).

4.7 Time-series of actual and predicted fuel moisture content using weather observations from 1200 (NZST)

Elevated layer

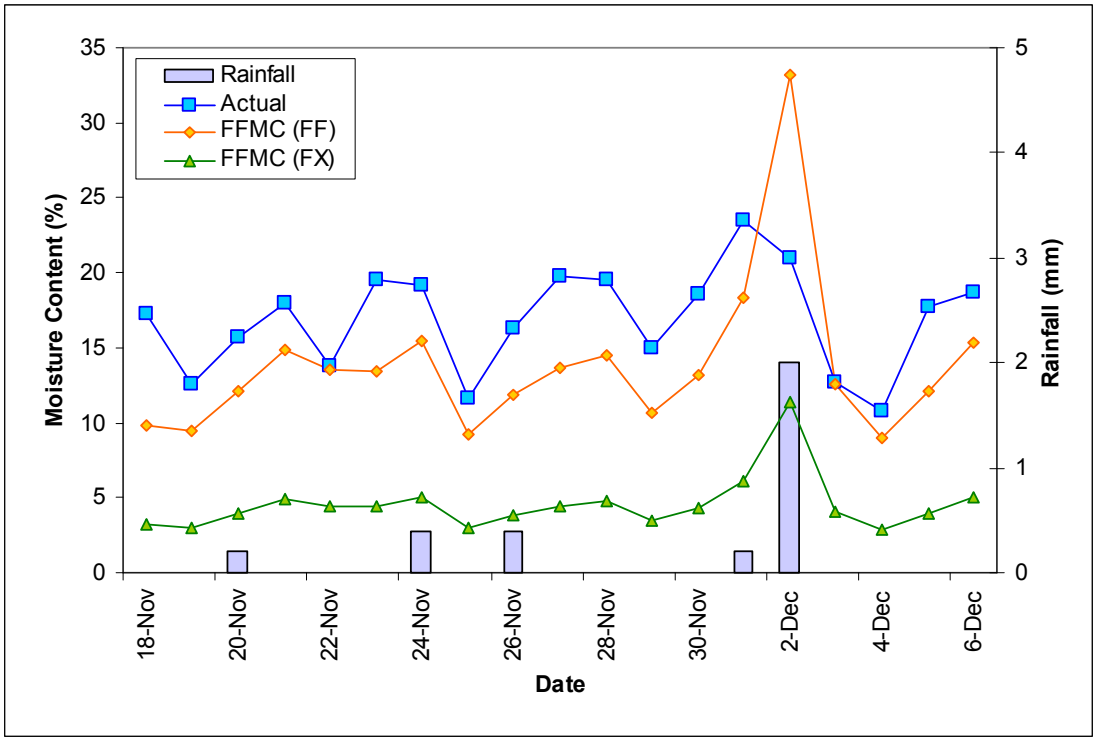


Figure 37. Time-series of actual and predicted moisture content for the elevated layer at Bottle Lake Forest from 18 November to 6 December 2008.

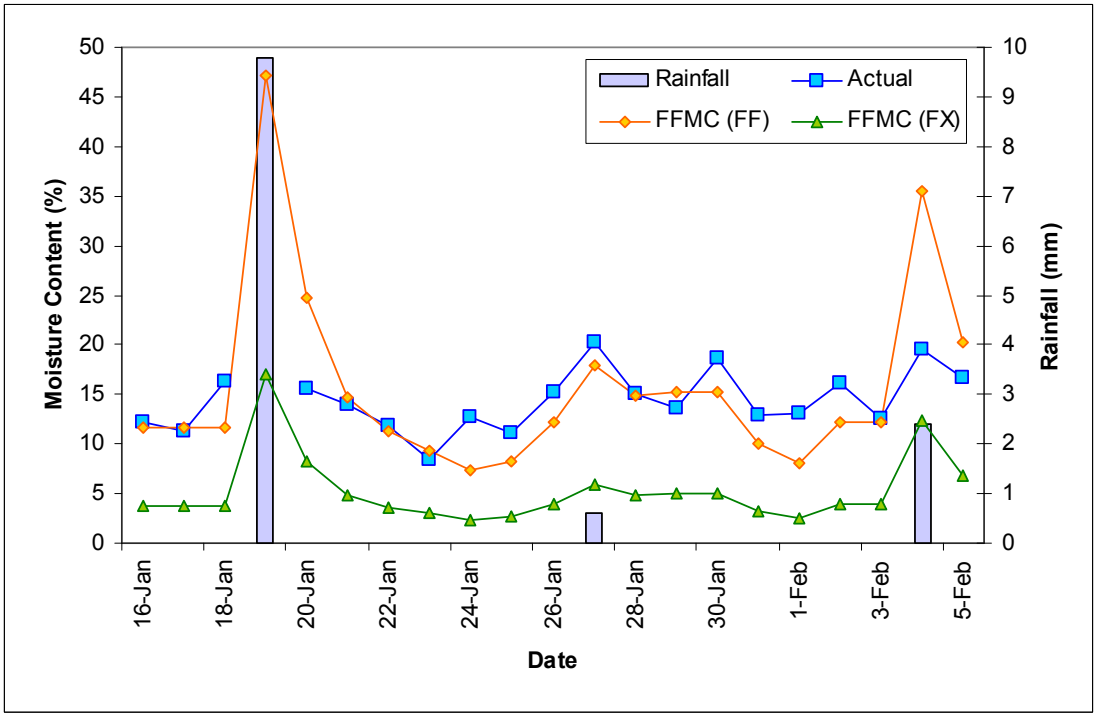


Figure 38. Time-series of actual and predicted moisture content for the elevated layer at McLeans Island Forest from 16 January to 5 February 2009.

Surface layer

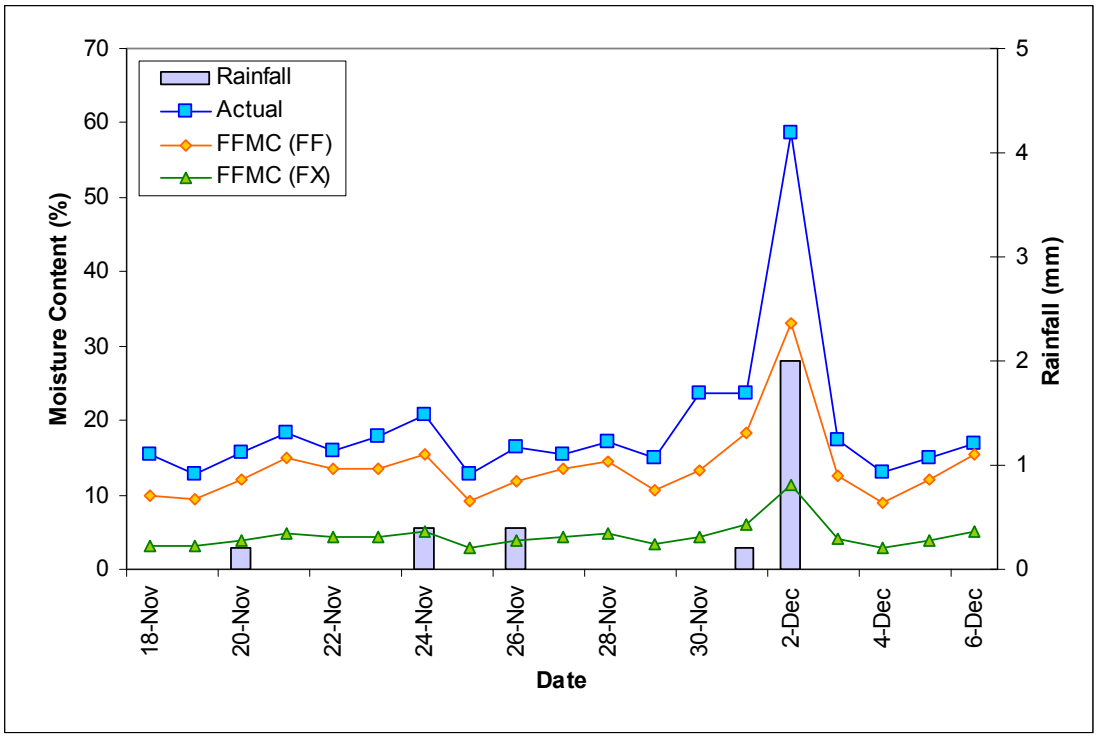


Figure 39. Time-series of actual and predicted moisture content for the surface layer at Bottle Lake Forest from 18 November to 6 December 2008.

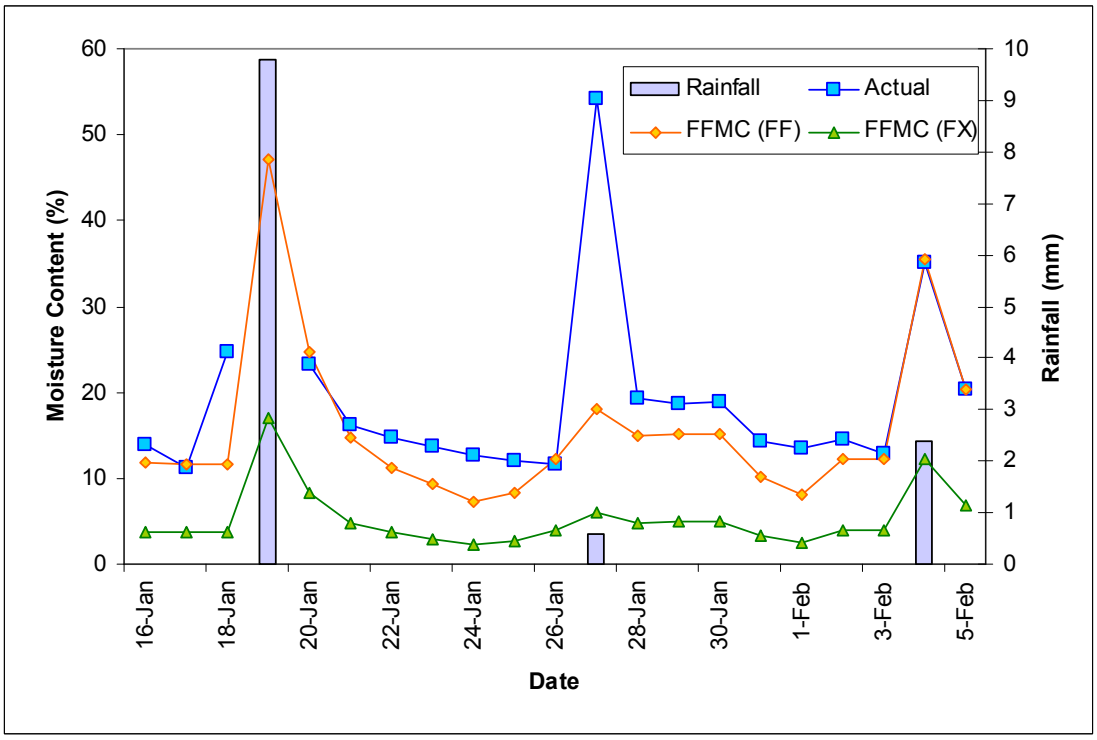


Figure 40. Time-series of actual and predicted moisture content for the surface layer at McLeans Island Forest from 16 January to 5 February 2009.

Loose duff layer

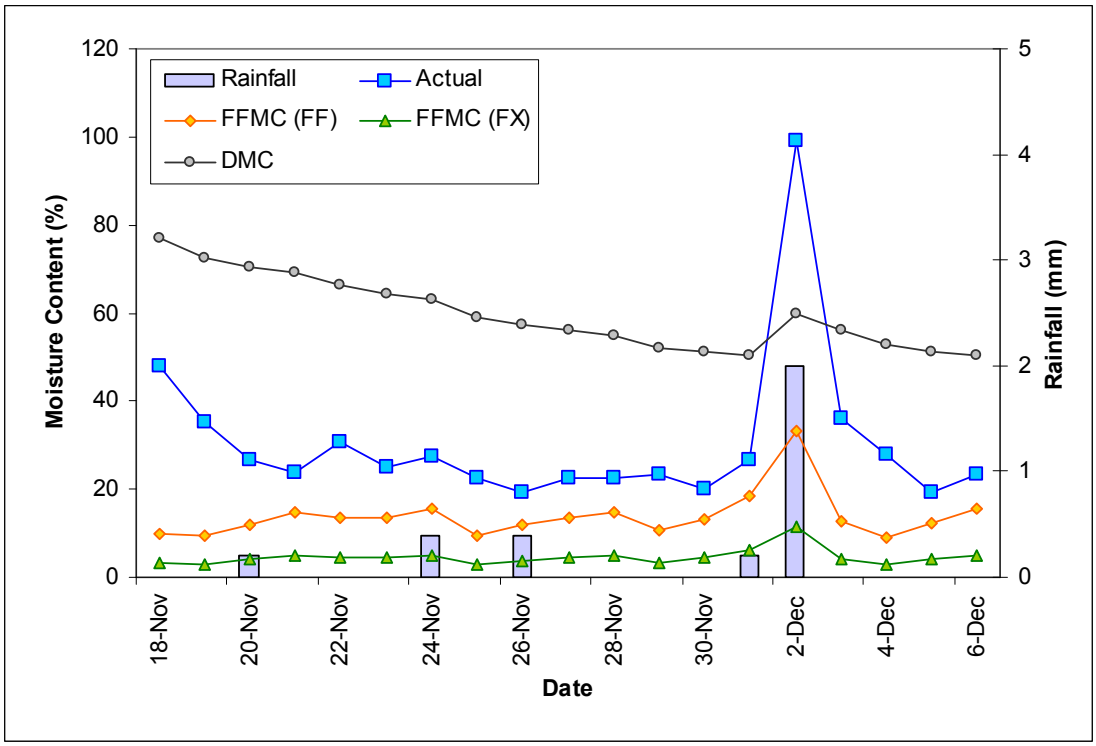


Figure 41. Time-series of actual and predicted moisture content for the loose duff layer at Bottle Lake Forest from 18 November to 6 December 2008.

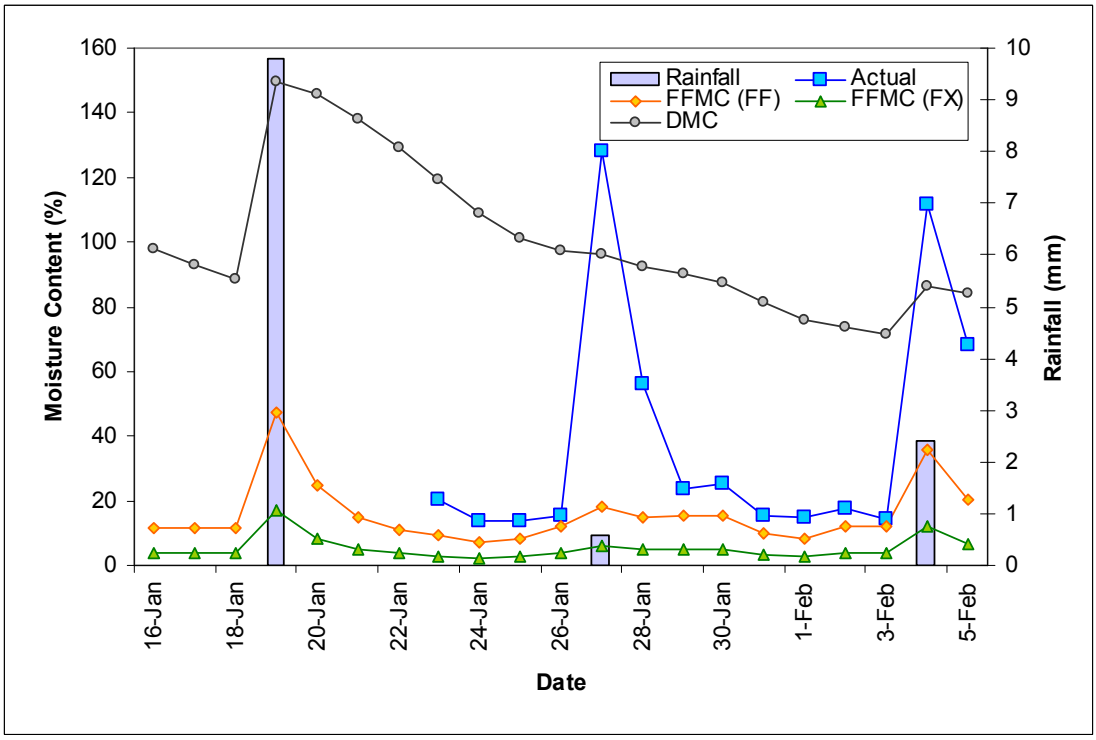


Figure 42. Time-series of actual and predicted moisture content for the loose duff layer at McLeans Island Forest from 16 January to 5 February 2009.

Compact duff layer

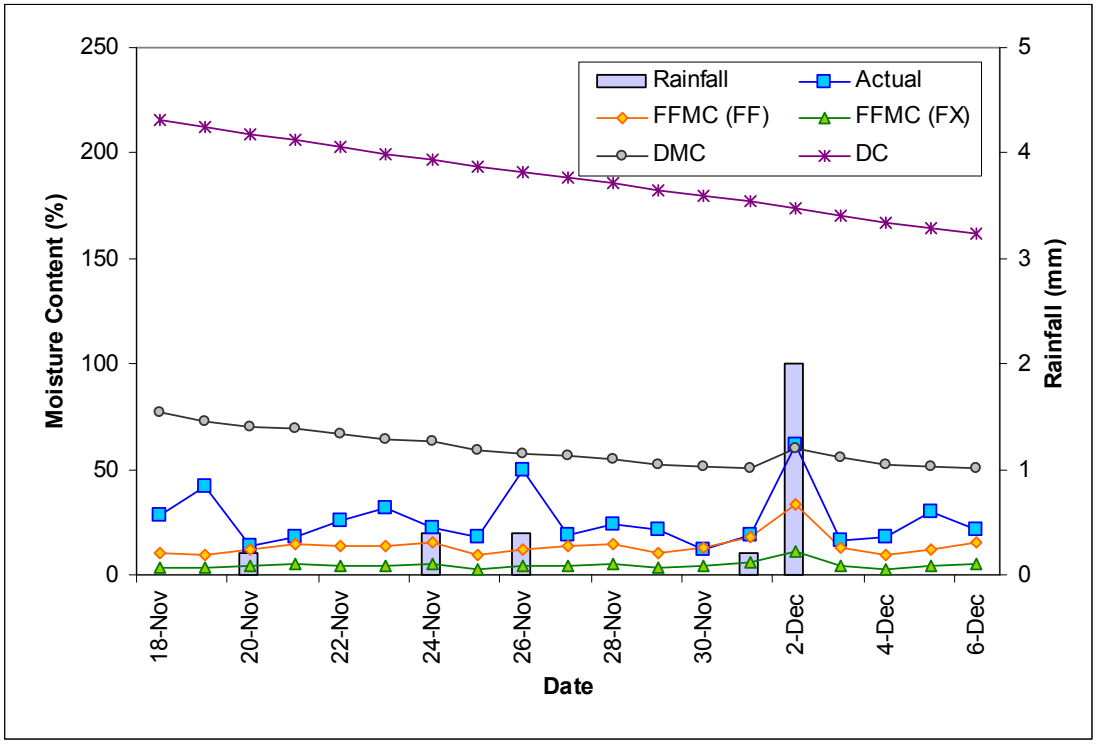


Figure 43. Time-series of actual and predicted moisture content for the compact duff layer at Bottle Lake Forest from 18 November to 6 December 2008.

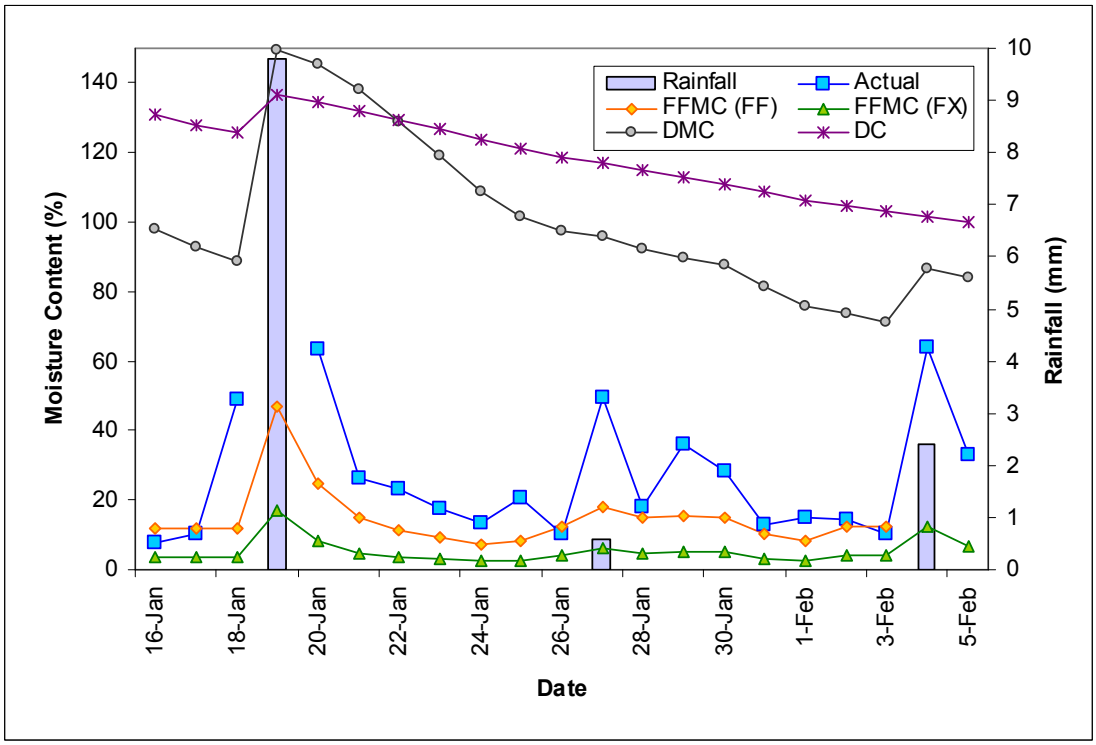


Figure 44. Time-series of actual and predicted moisture content for the compact duff layer at McLeans Island Forest from 16 January to 5 February 2009.

4.8 Actual versus predicted moisture content using weather observations from 1200 (NZST)

Elevated layer

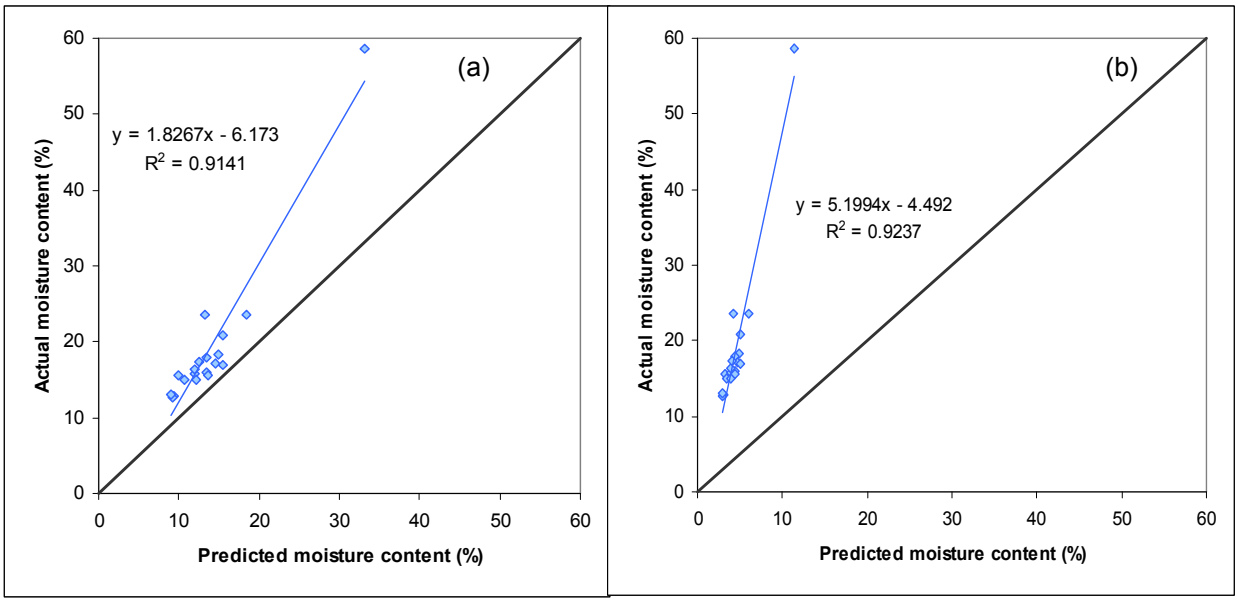


Figure 45. Actual versus predicted moisture content for the elevated layer at Bottle Lake Forest: (a) FF-scale, (b) FX-scale of the FFMC.

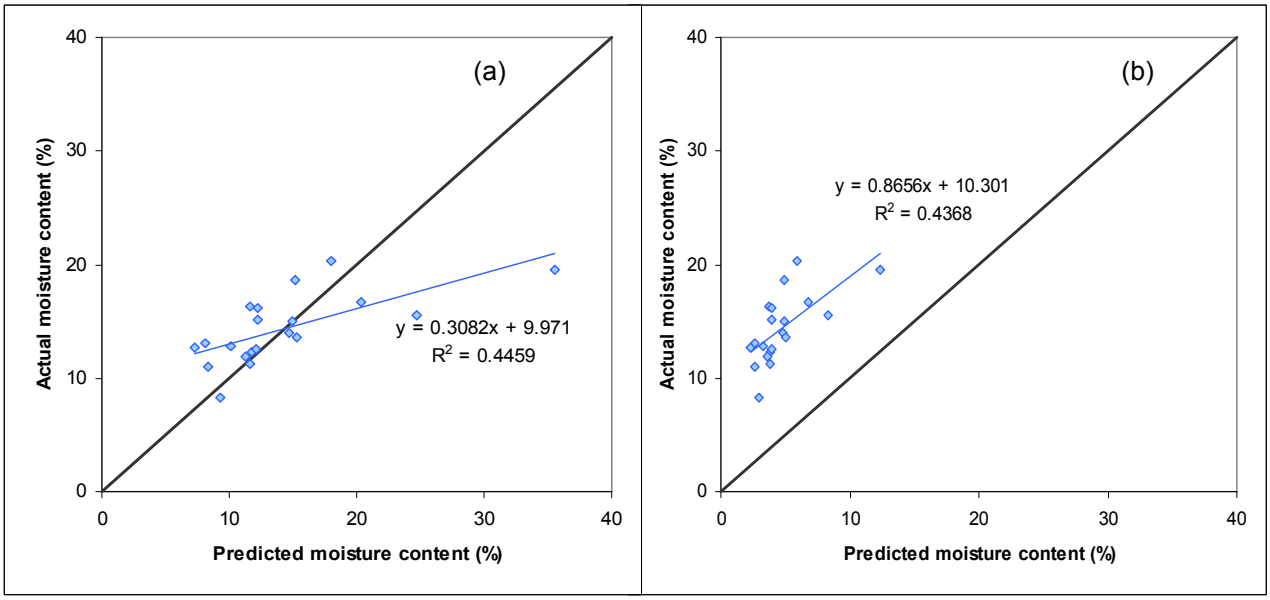


Figure 46. Actual versus predicted moisture content for the elevated layer at McLeans Island Forest: (a) FF-scale, (b) FX-scale of the FFMC.

Surface layer

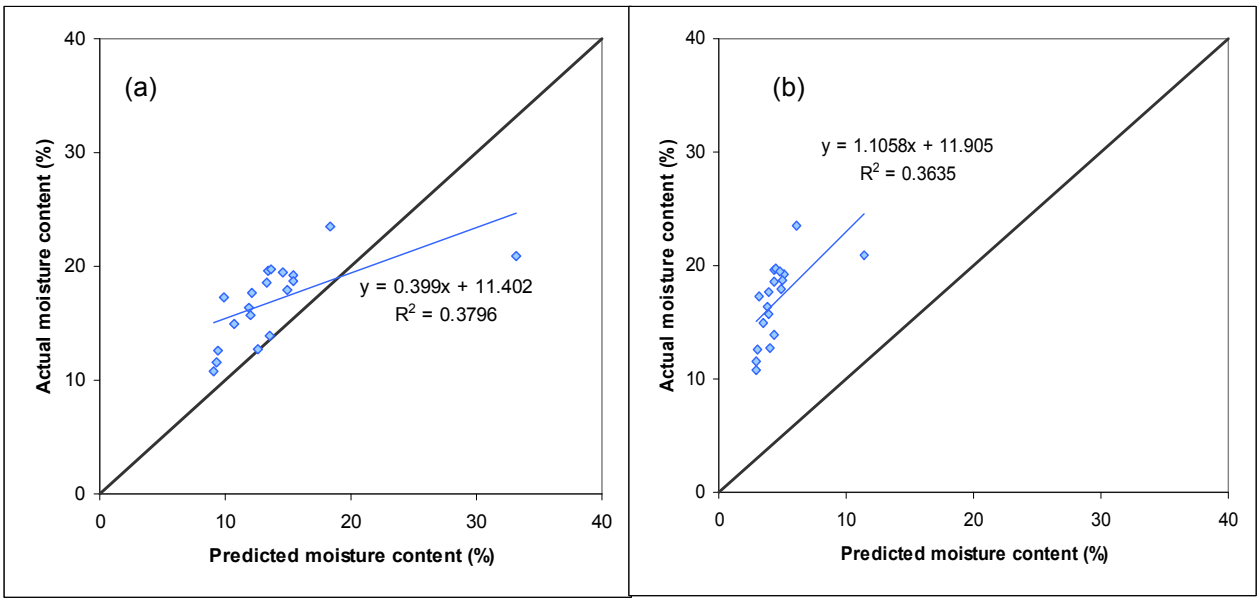


Figure 47. Actual versus predicted moisture content for the surface layer at Bottle Lake Forest: (a) FF-scale, (b) FX-scale of the FFMC.

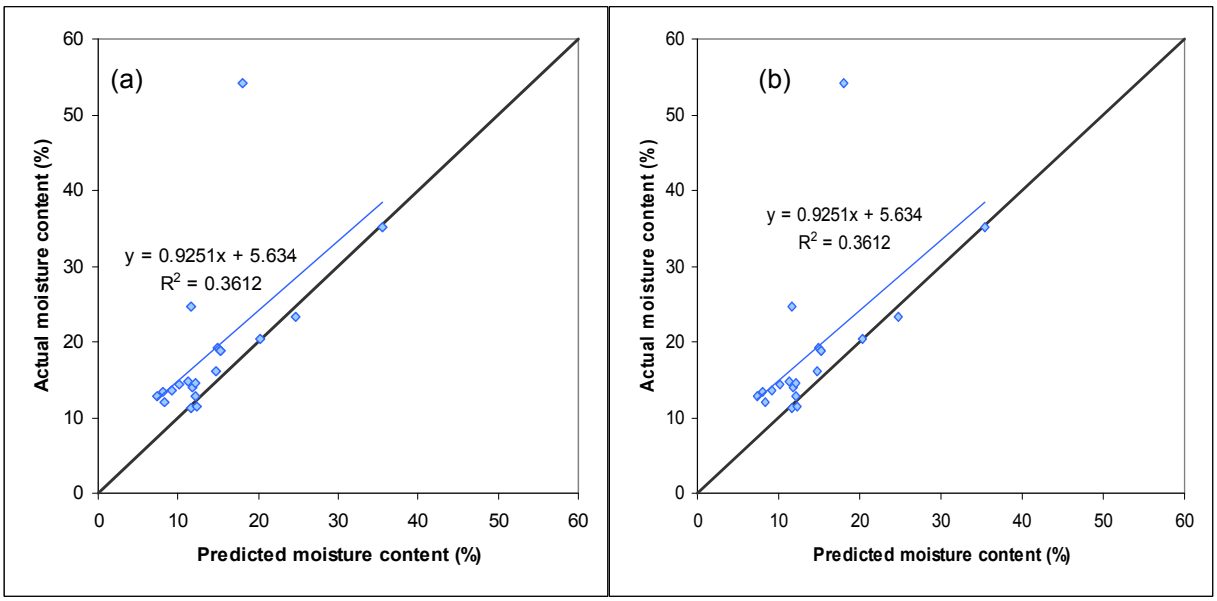


Figure 48. Actual versus predicted moisture content for the surface layer at McLeans Island Forest: (a) FF-scale, (b) FX-scale of the FFMC.

Loose duff layer

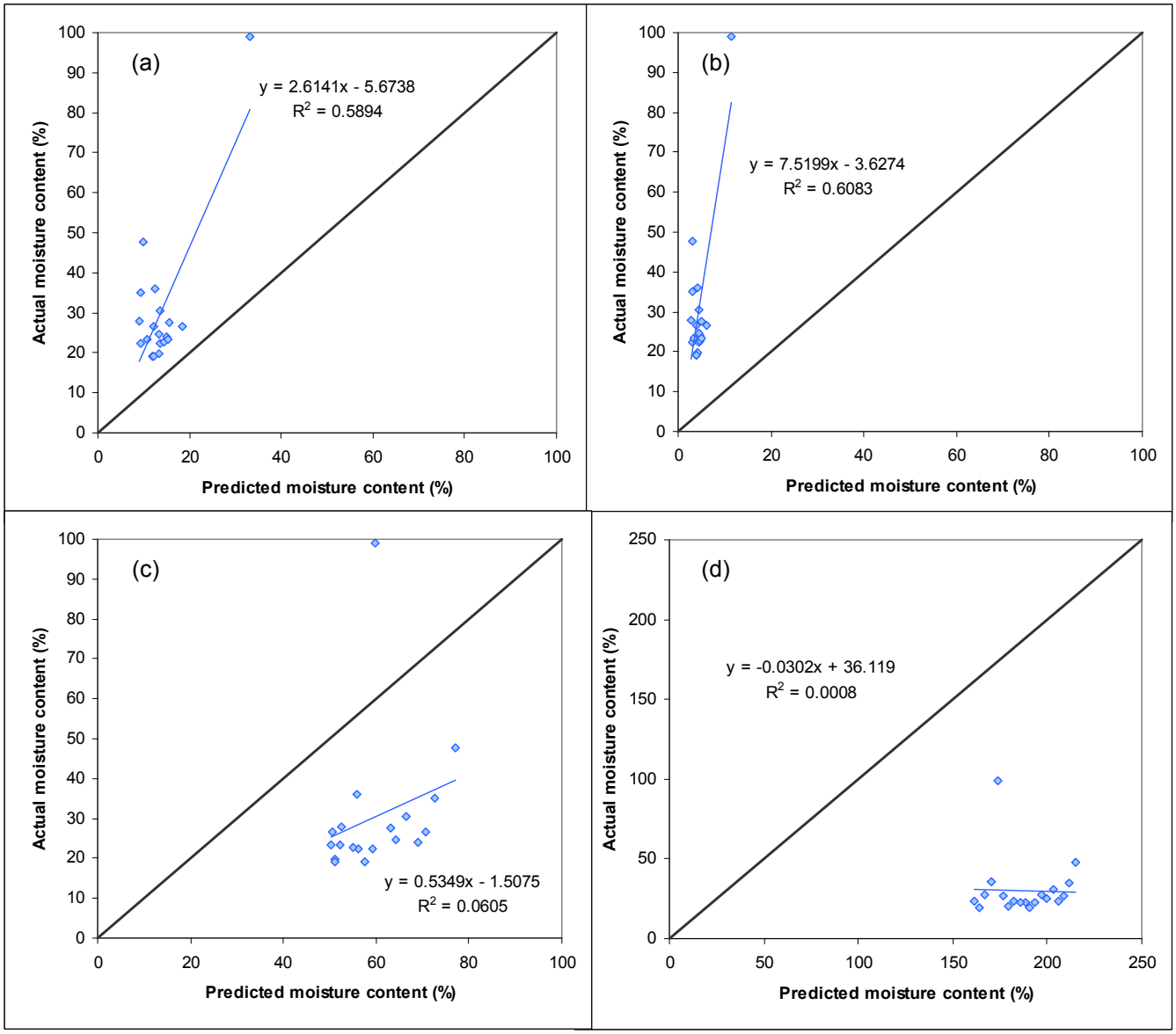


Figure 49. Actual versus predicted moisture content for the loose duff layer at Bottle Lake Forest: (a) FFMC (FF-scale), (b) FFMC (FX-scale), DMC (c), DC (d).

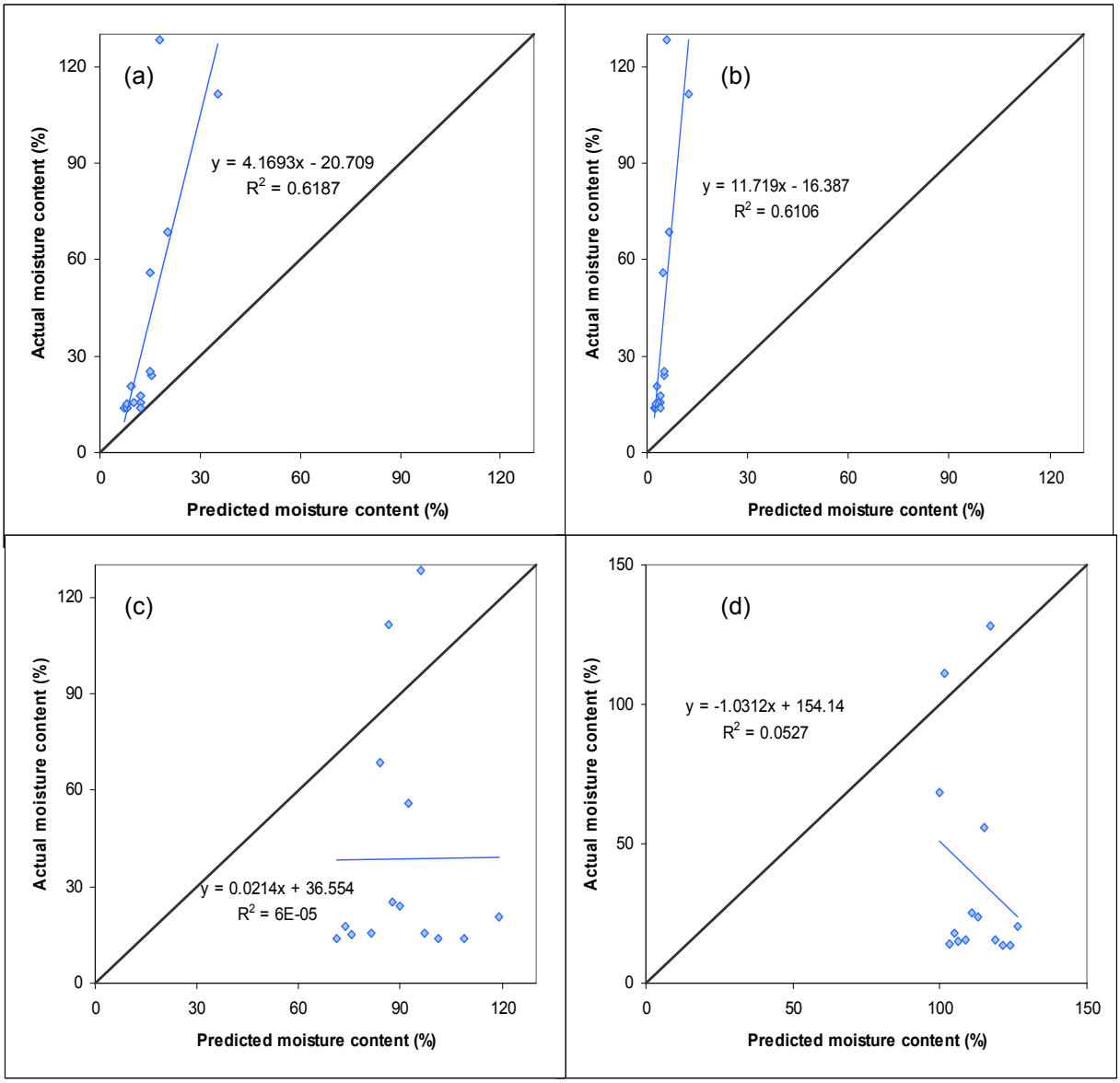


Figure 50. Actual versus predicted moisture content for the loose duff layer at McLeans Island Forest: (a) FF-scale, (b) FX-scale, DMC (c), DC (d).

Compact duff layer

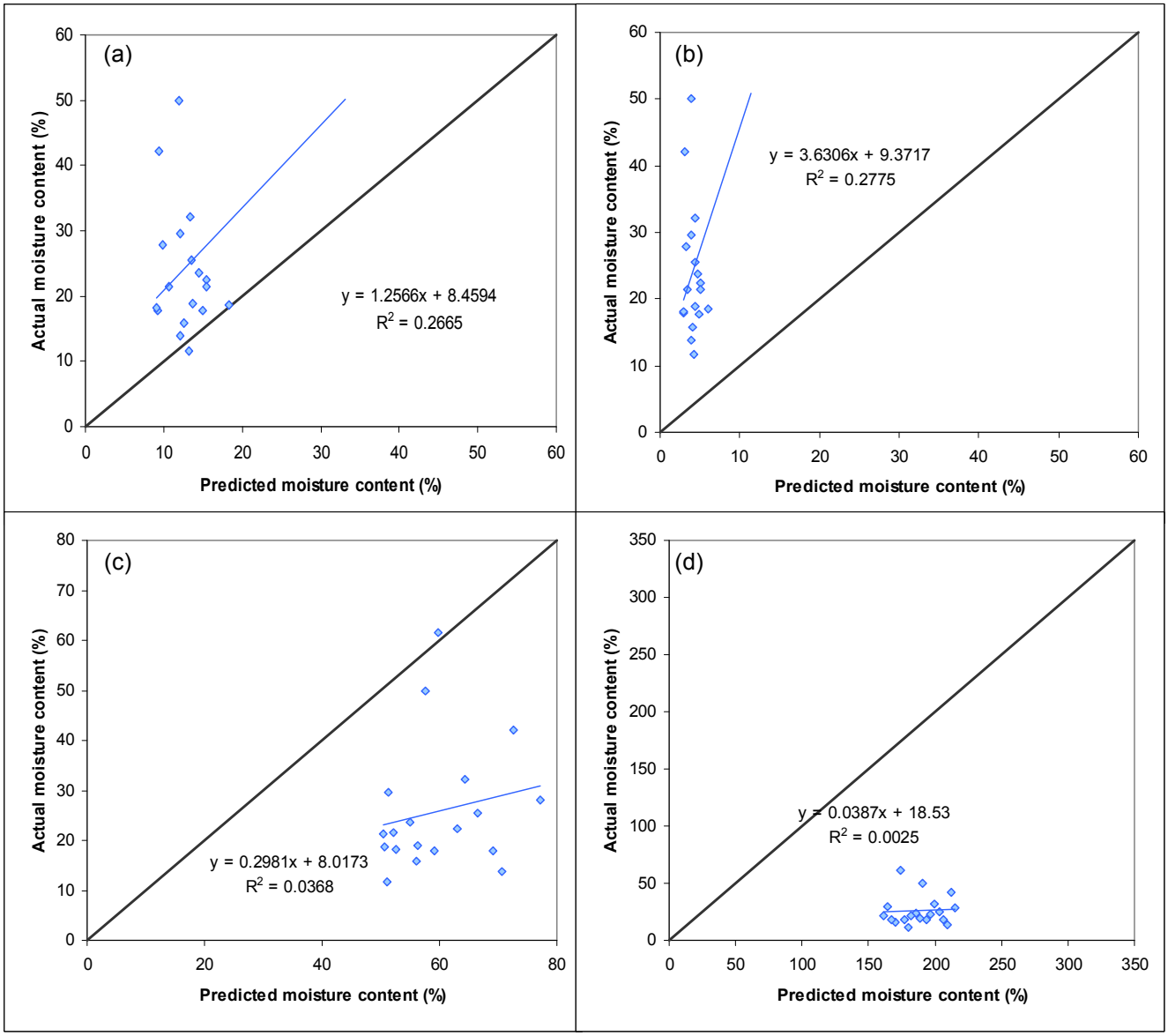


Figure 51. Actual versus predicted moisture content for the compact duff layer at Bottle Lake Forest: FF-scale (a), FX-scale (b), DMC (c), and DC (d).

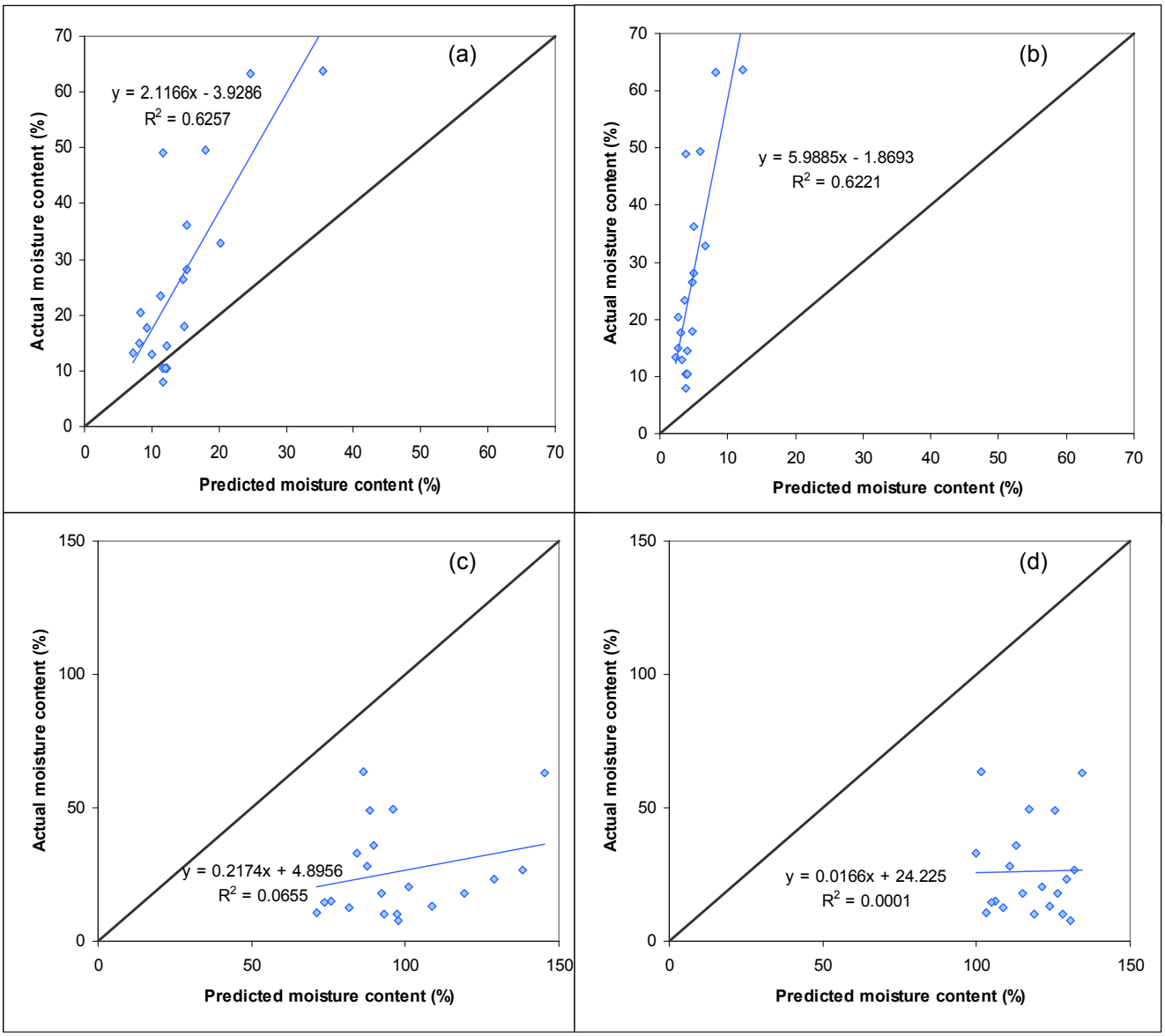


Figure 52. Actual versus predicted moisture content for the compact duff layer at McLeans Island Forest: FF-scale (a), FX-scale (b), DMC (c), and DC (d).

Table 17. Statistical comparison of the actual versus predicted fuel moisture content sampled and calculated from Bottle Lake Forest (Source: Bottle Lake RAWS, NRFA) (n = 19).

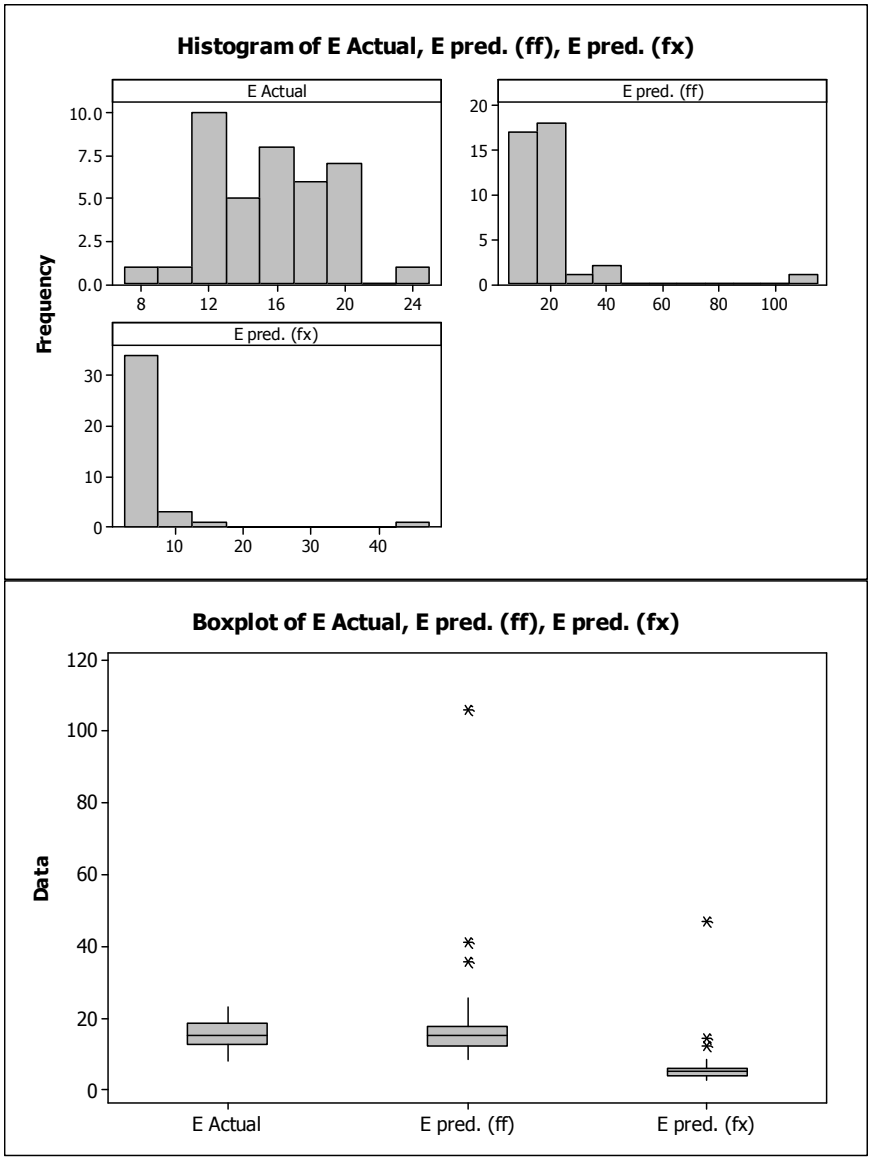
	FFMC (FF-scale)	**FFMC** (FX-scale)	**DMC**	**DC**
Elevated				
RMSE	5.1	12.7		
ME	3.1	12.4		
R^2	0.4	0.4		
Surface				
RMSE	7.3	16.6		
ME	5.2	14.5		
R^2	0.9	0.9		
Loose				
RMSE	21.7	30.5	34.0	159.65
ME	16.6	25.9	-29.3	-157.79
R^2	0.6	0.6	0.1	0
Compact				
RMSE	16.1	24.3	36.5	163.6
ME	12.0	21.3	-33.9	-162.4
R^2	0.3	0.3	0.0	0.0

Table 18. Statistical comparison of the actual versus predicted fuel moisture content sampled and calculated from McLeans Island Forest (Source: Bottle Lake RAWS, NRFA).

		FFMC (FF-scale)	**FFMC** (FX-scale)	**DMC**	**DC**
Elevated	n	20	20		
	RMSE	5.1	10.0		
	ME	0.1	9.7		
	R^2	0.4	0.4		
Surface	n	20	20		
	RMSE	9.3	16.7		
	ME	4.7	14.1		
	R^2	0.4	0.4		
Loose	n	14	14	14	14
	RMSE	40.0	48.7	65.0	83.66
	ME	24.3	33.8	-51.9	-73.66
	R^2	0.6	0.6	0.00	0.05
Compact	n	20	20	20	20
	RMSE	17.8	24.0	74.9	94.6
	ME	12.1	19.7	-71.1	-92.4
	R^2	0.6	0.6	0.1	0.0

4.9 Data analysis

For combined elevated moisture content using 1600 (NZST) weather



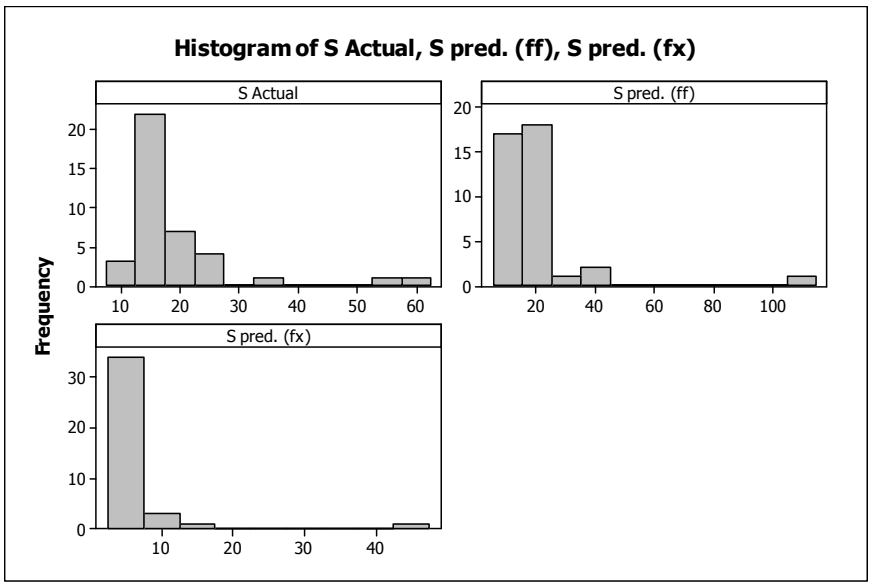
One-way ANOVA: E Actual, E pred. (ff), E pred. (fx)

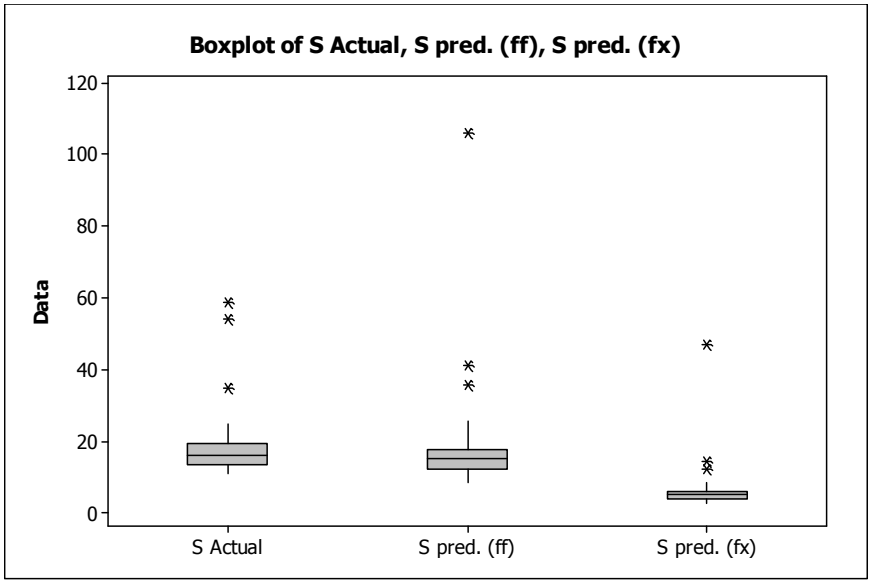
Source	DF	SS	MS	F	P
Factor	2	3148	1574	15.31	0.000
Error	114	11724	103		
Total	116	14872			

S = 10.14 R-Sq = 21.17% R-Sq(adj) = 19.79%

```
                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level           N   Mean  StDev  ---+---------+---------+---------+------
E Actual       39  15.60   3.44                    (-----*------)
E pred. (ff)   39  18.74  15.72                          (-----*------)
E pred. (fx)   39   6.51   7.05  (-----*-----)
                                  ---+---------+---------+---------+------
                                   5.0      10.0      15.0      20.0

Pooled StDev = 10.14


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons

Individual confidence level = 98.08%


E Actual subtracted from:

                Lower  Center  Upper  --------+---------+---------+---------
E pred. (ff)    -2.32    3.14   8.59                   (----*-----)
E pred. (fx)   -14.55   -9.09  -3.64      (-----*----)
                                        --------+---------+---------+---------
                                              -10         0        10        20

E pred. (ff) subtracted from:

                Lower  Center  Upper  --------+---------+---------+---------
E pred. (fx)   -17.69  -12.23  -6.78   (-----*----)
                                        --------+---------+---------+---------
                                              -10         0        10        20
```

Surface moisture content using 1600 (NZST) weather

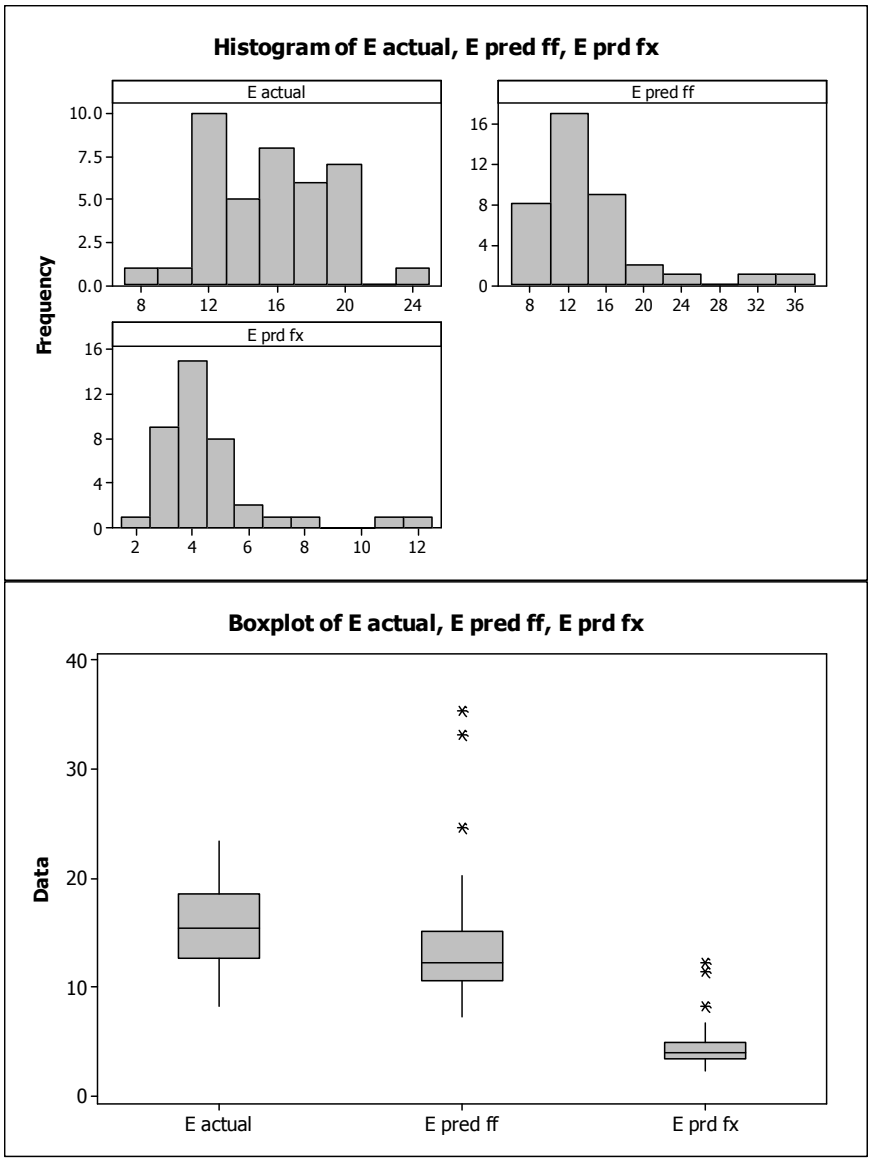




One-way ANOVA: S Actual, S pred. (ff), S pred. (fx)

```
Source   DF     SS    MS      F      P
Factor    2   3949  1975  14.96  0.000
Error   114  15047   132
Total   116  18997

S = 11.49   R-Sq = 20.79%   R-Sq(adj) = 19.40%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev  ----+---------+---------+---------+-----
S Actual      39  18.92   9.96                          (------*------)
S pred. (ff)  39  18.74  15.72                          (------*-------)
S pred. (fx)  39   6.51   7.05  (------*------)
                                  ----+---------+---------+---------+-----
                                    5.0      10.0      15.0      20.0

Pooled StDev = 11.49


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons

Individual confidence level = 98.08%


S Actual subtracted from:

               Lower  Center  Upper  ---------+---------+---------+---------
S pred. (ff)   -6.37   -0.18   6.00              (-----*-----)
S pred. (fx)  -18.60  -12.42  -6.23  (------*-----)
                                     ---------+---------+---------+---------
                                            -10         0        10


S pred. (ff) subtracted from:

               Lower  Center  Upper  ---------+---------+---------+---------
S pred. (fx)  -18.41  -12.23  -6.05   (-----*-----)
                                     ---------+---------+---------+---------
                                            -10         0        10
```

For combined elevated moisture content using 12noon (NZST) weather



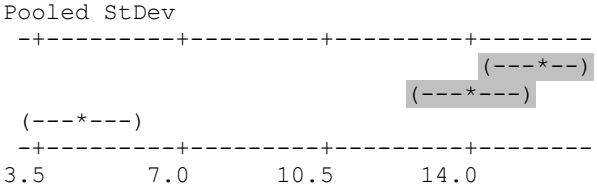
One-way ANOVA: E actual, E pred ff, E prd fx

Source	DF	SS	MS	F	P
Factor	2	2755.8	1377.9	81.15	0.000
Error	114	1935.6	17.0		
Total	116	4691.4			

S = 4.121 R-Sq = 58.74% R-Sq(adj) = 58.02%

Level	N	Mean	StDev
E actual	39	15.602	3.437
E pred ff	39	14.024	5.899
E prd fx	39	4.609	2.081

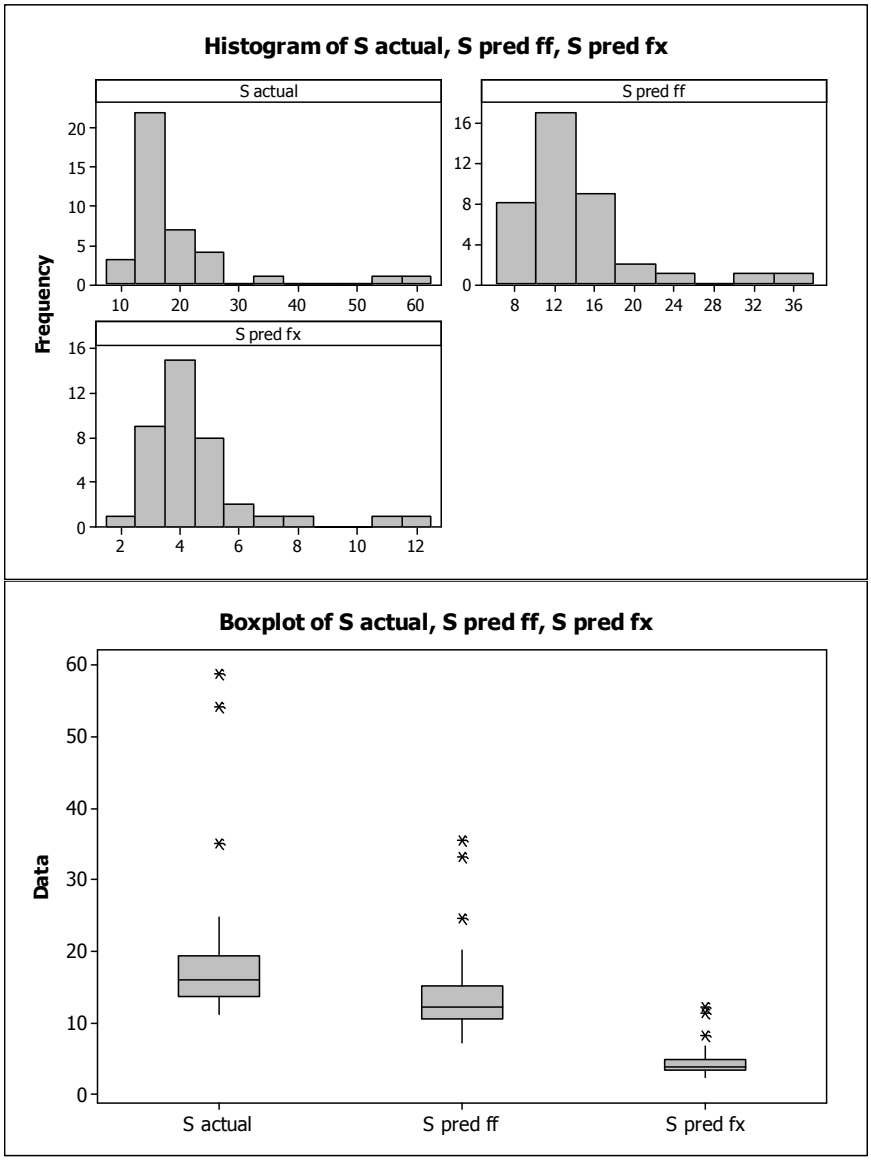
Individual 95% CIs For Mean Based on Pooled StDev



Pooled StDev = 4.121

```
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons

Individual confidence level = 98.08%


E actual subtracted from:

             Lower   Center   Upper  ---------+---------+---------+---------
E pred ff   -3.795   -1.578   0.639                  (--*--)
E prd fx   -13.210  -10.993  -8.776  (--*--)
                                     ---------+---------+---------+---------
                                           -7.0        0.0        7.0
```

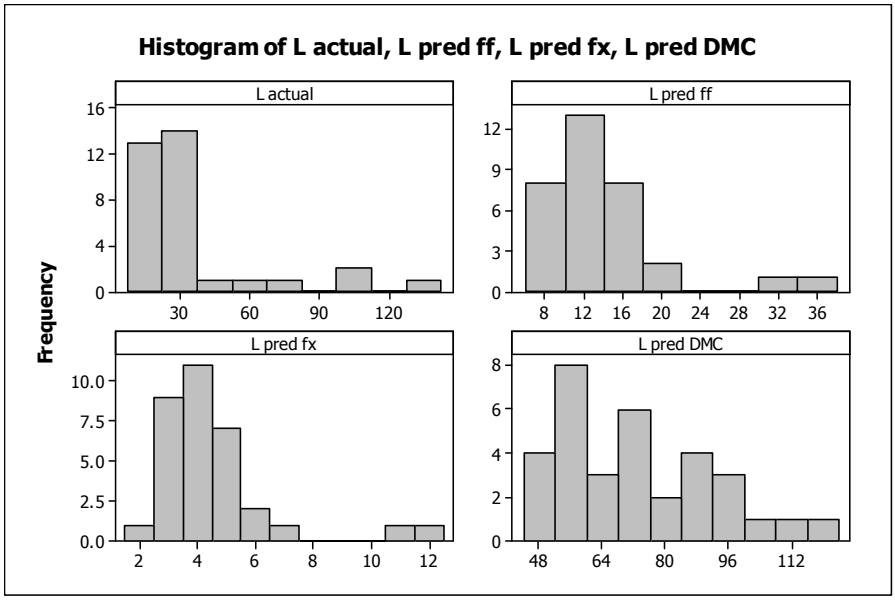
Surface moisture content using 12noon (NZST) weather

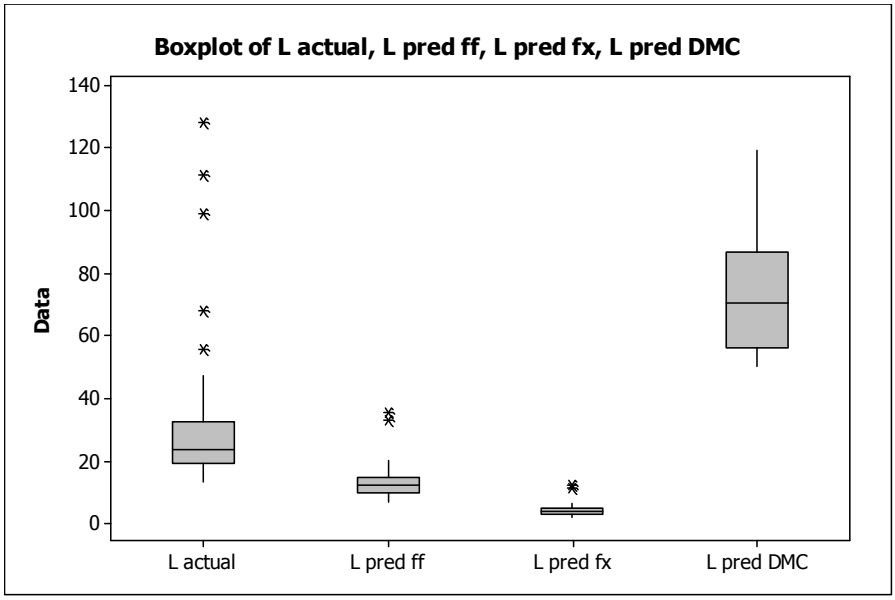


One-way ANOVA: S actual, S pred ff, S pred fx

```
Source   DF      SS      MS      F      P
Factor    2  4127.9  2063.9  44.74  0.000
Error   114  5259.5    46.1
Total   116  9387.4

S = 6.792   R-Sq = 43.97%   R-Sq(adj) = 42.99%


                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level       N    Mean  StDev  -----+---------+---------+---------+----
S actual   39  18.922  9.964                              (---*---)
S pred ff  39  14.024  5.899                    (---*---)
S pred fx  39   4.609  2.081  (---*----)
                               -----+---------+---------+---------+----
                                  5.0      10.0      15.0      20.0

Pooled StDev = 6.792


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons

Individual confidence level = 98.08%


S actual subtracted from:

             Lower   Center    Upper
S pred ff   -8.553   -4.899   -1.244
S pred fx  -17.968  -14.314  -10.659

             --+---------+---------+---------+-------
S pred ff              (----*---)
S pred fx    (---*----)
             --+---------+---------+---------+-------
           -16.0      -8.0       0.0       8.0
```

Loose duff moisture content using 12noon (NZST) weather

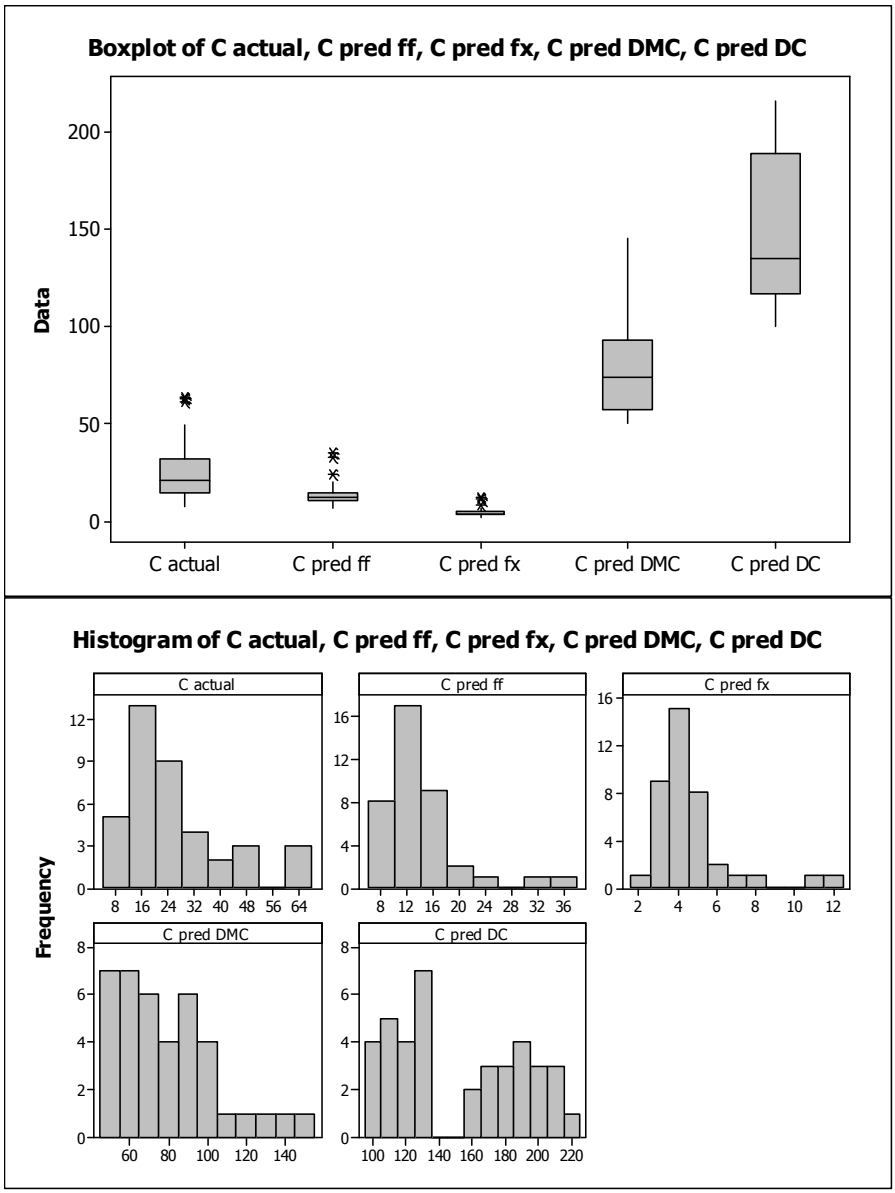




One-way ANOVA: L actual, L pred ff, L pred fx, L pred DMC

```
Source   DF      SS     MS       F      P
Factor    3   90280  30093  101.48  0.000
Error   128   37958    297
Total   131  128238

S = 17.22   R-Sq = 70.40%   R-Sq(adj) = 69.71%

                              Individual 95% CIs For Mean Based on
                              Pooled StDev
Level        N   Mean  StDev  -+---------+---------+---------+--------
L actual    33  33.85  28.21                (--*--)
L pred ff   33  13.98   6.08       (--*--)
L pred fx   33   4.59   2.15  (--*--)
L pred DMC  33  72.72  18.68                                   (--*--)
                              -+---------+---------+---------+--------
                               0         20        40        60

Pooled StDev = 17.22


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons

Individual confidence level = 98.96%


L actual subtracted from:

             Lower  Center   Upper    +---------+---------+---------+-------
--
L pred ff   -30.91  -19.87   -8.84               (--*--)
L pred fx   -40.29  -29.26  -18.23              (--*-)
L pred DMC   27.84   38.87   49.90                                (--*-)
                                     +---------+---------+---------+-------
--
                                   -80       -40         0        40
```

Compact duff moisture content using 12noon (NZST) weather



One-way ANOVA: C actual, C pred ff, C pred fx, C pred DMC, C pred DC

Source	DF	SS	MS	F	P
Factor	4	587025	146756	309.96	0.000
Error	190	89959	473		
Total	194	676984			

S = 21.76 R-Sq = 86.71% R-Sq(adj) = 86.43%

```
 Individual 95% CIs For Mean Based on
                                Pooled StDev
Level        N    Mean  StDev  +---------+---------+---------+---------
C actual    39   26.00  15.25       (*-)
C pred ff   39   14.02   5.90     (-*)
C pred fx   39    4.61   2.08   (*)
C pred DMC  39   79.29  24.89                 (-*)
C pred DC   39  151.97  38.42                                (*-)
                                +---------+---------+---------+---------
                                0        50       100       150

Pooled StDev = 21.76


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons

Individual confidence level = 99.36%


C actual subtracted from:

             Lower  Center   Upper  ------+---------+---------+---------+---
C pred ff   -25.57  -11.98    1.61               (-*)
C pred fx   -34.98  -21.39   -7.80               (*)
C pred DMC   39.70   53.29   66.87                       (*-)
C pred DC   112.38  125.97  139.56                              (-*)
                                   ------+---------+---------+---------+---
                                      -100         0       100       200
```

Appendix 5. Hourly data

5.1 Daily fire weather conditions before sampling

Bottle Lake Forest 10/2/09
The day before sampling at 1200 (NZST), the temperature reached 34.5ºC with a relative humidity of 29% and a FFMC value of 93 (Table 19). A week before sampling the average temperature was 24ºC, relative humidity 54% and FFMC 85. Significant rainfall (2.2 mm) occurred 5 days before sampling. Because sampling followed a very hot day with low relative humidity, and a rain-free period of five days, the fine fuels were considered to be in a drying cycle.

Bottle Lake Forest 19/03/09
The day before sampling at 1200 (NZST), the temperature was 19ºC with a relative humidity of 63% and FFMC 85 (Table 20). A week before sampling the average temperature was 18ºC, RH 63% and FFMC 80. Significant rainfall (2.6 mm) occurred 7 days before sampling. Because sampling followed a rain-free period of five days, the fine fuels were considered to be in a drying cycle

McLeans Island Forest 23/01/09
A day before sampling at 1200 (NZST), the temperature was 15ºC, RH 54% and FFMC 89 (Table 21). A week before sampling the average temperature was 20ºC, RH 54% and FFMC 88. Significant rain fell (0.6 mm) 7 days before sampling. Because sampling followed a rain-free period of 7 days, the fine fuels were considered to be in a drying cycle.

McLeans Island Forest 3/02/09
The day before sampling, weather at 1200 (NZST), was 26ºC, RH 40% and FFMC 90 (Table 22). A week before sampling the average temperature was 22ºC, RH 49% and FFMC 83. Four days before sampling, significant rain fell (9.8 mm). Because sampling followed a rain-free period of 4 days, the fine fuels were considered to be in a drying cycle.

Table 19. Daily fire weather observations from 3 to 10 February 2009 from Bottle Lake Forest RAWS (Source: NRFA).

Date	Temp (°C)	RH (%)	Wind dir (deg)	Wind spd (km/h)	Rain (mm)	FFMC	DMC	DC	ISI	BUI	FWI
3/02/2009	22	54	106	5	0	88.8	112	683	4.7	159	22.2
4/02/2009	18.3	70	223	7.3	**1.4**	77.5	113	689	1.3	161	8.2
5/02/2009	21.2	63	58	8.7	**2.2**	72.6	94	696	1.1	140	6.5
6/02/2009	26.1	48	71	6	0	85.3	97	703	3.0	144	15.5
7/02/2009	21.8	41	107	11.2	0	88.5	99	710	6.1	147	26.2
8/02/2009	21.5	72	77	10	0	85.9	100	717	3.9	149	19.3
9/02/2009	34.6	29	276	4.2	0	93.1	105	726	8.2	155	32.6
10/02/2009	17.9	64	112	10	0	87.8	107	733	5.1	157	23.7
1 week before sampling											
Average	23.6	53.9	131.1	7.5	0.5	84.5	103.0	703.5	4.0	150.6	18.6
Median	21.8	54.0	106.0	7.3	0.0	85.9	100.5	703.4	3.9	148.8	19.3
Min	18.3	29.0	58.0	4.2	0.0	72.6	93.7	682.6	1.1	140.2	6.5
Max	34.6	72.0	276.0	11.2	2.2	93.1	113.3	726.5	8.2	160.6	32.6
Total rainfall					3.6						

Table 20. Daily fire weather observations from 12 to 19 March 2009 from Bottle Lake Forest RAWS (Source: NRFA).

Date	Temp (°C)	RH (%)	Wind dir (deg)	Wind spd (km/h)	Rain (mm)	FFMC	DMC	DC	ISI	BUI	FWI
12/03/2009	18.9	58	315	2.4	**2.6**	64.6	13	549	0.6	24	0.6
13/03/2009	16.1	58	216	13.2	**0.2**	78.5	14	553	1.9	27	3.7
14/03/2009	18	62	51	7.8	0	82.8	15	558	2.3	29	4.8
15/03/2009	17.5	65	88	11.8	0	83.9	17	563	3.3	31	7.0
16/03/2009	19.2	70	81	10.8	0	84.0	18	568	3.2	33	7.0
17/03/2009	19.4	68	53	8.5	0	84.1	19	573	2.9	35	6.7
18/03/2009	18.8	63	95	7.8	0	84.7	20	579	3.0	37	7.2
19/03/2009	26.4	31	287	6.6	0	90.9	23	585	6.8	42	15.4
1 week before sampling											
Average	18.3	63.4	128.4	8.9	0.4	80.4	16.5	563.4	2.5	30.7	5.3
Median	18.8	63.0	88.0	8.5	0.0	83.9	16.6	563.1	2.9	30.8	6.7
Min	16.1	58.0	51.0	2.4	0.0	64.6	12.9	548.7	0.6	24.4	0.6
Max	19.4	70.0	315.0	13.2	2.6	84.7	20.0	578.6	3.3	36.9	7.2
Total rainfall					2.8						

Table 21. Daily fire weather observations from 27 to 3 February 2009 from Christchurch Aero RAWS (Source: NIWA).

Date	Temp (°C)	RH (%)	Wind dir (deg)	Wind spd (km/h)	Rain (mm)	FFMC	DMC	DC	ISI	BUI	FWI
27/01/2009	13	77	180	32	**0.6**	83.51	56.66	491.88	8.66	87.98	26.82
28/01/2009	18	48	110	6	0	86.25	58.82	498.82	3.39	90.86	13.78
29/01/2009	19	67	220	9	0	85.94	60.27	505.94	3.78	92.88	15.16
30/01/2009	19	66	60	19	0	85.99	61.76	513.07	6.30	94.94	22.33
31/01/2009	28	37	60	26	0	90.71	65.75	521.81	17.59	100.00	45.52
1/02/2009	30	30	230	11	0	92.64	70.08	530.22	10.86	105.35	34.09
2/02/2009	15	54	180	17	0	88.72	71.55	535.92	8.40	107.29	28.92
3/02/2009	19	48	90	9	0	88.76	73.63	542.34	5.65	109.95	22.20
1 week before sampling											
Average	20.3	54.1	148.6	17.1	0.1	87.7	63.6	514.0	8.4	97.0	26.7
Median	19.0	54.0	180.0	17.0	0.0	86.3	61.8	513.1	8.4	94.9	26.8
Min	13.0	30.0	60.0	6.0	0.0	83.5	56.7	491.9	3.4	88.0	13.8
Max	30.0	77.0	230.0	32.0	0.6	92.6	71.6	535.9	17.6	107.3	45.5
Total rainfall					0.6						

Table 22. Daily fire weather observations from 16 to 23 January 2009 from Christchurch Aero RAWS (Source: NIWA).

Date	Temp (°C)	RH (%)	Wind dir (deg)	Wind spd (km/h)	Rain (mm)	FFMC	DMC	DC	ISI	BUI	FWI
16/01/2009	26	45	60	19	0	89.15	55.53	447.51	9.88	84.76	28.82
17/01/2009	24	47	50	24	0	89.20	58.43	455.53	12.80	88.48	35.02
18/01/2009	21	46	90	15	0	89.25	61.03	463.02	8.19	91.80	26.38
19/01/2009	18	53	40	15	**9.8**	62.06	33.42	429.12	0.98	55.95	3.05
20/01/2009	16	62	70	22	0	77.94	34.84	435.71	2.84	58.06	9.12
21/01/2009	22	48	80	22	0	86.43	37.45	443.37	7.79	61.84	20.75
22/01/2009	26	40	80	9	0	89.61	40.99	451.76	6.38	66.83	18.70
23/01/2009	27	33	90	19	0	91.52	45.09	460.32	13.87	72.45	33.48
1 week before sampling											
Average	21.9	48.7	67.1	18.0	1.4	83.4	46.0	446.6	7.0	72.5	20.3
Median	22.0	47.0	70.0	19.0	0.0	89.1	41.0	447.5	7.8	66.8	20.8
Min	16.0	40.0	40.0	9.0	0.0	62.1	33.4	429.1	1.0	55.9	3.1
Max	26.0	62.0	90.0	24.0	9.8	89.6	61.0	463.0	12.8	91.8	35.0
Total rainfall					9.8						

5.2 Hourly Fire Weather during sampling

Bottle Lake Forest

Table 23. Hourly fire weather observations for Bottle Lake Forest on 10 February 2009 (Source: NRFA) (Shaded area was the sampling period).

Time (NZST)	**Temp** (ºC)	**RH** (%)	**Wind dir** (degrees)	**Wind spd** (km/h)	**Rain** (mm)	**FFMC**	**ISI**	**FWI**
0:00	16.5	54	76	8.2	0	88.0	4.9	22.7
1:00	16.2	61	97	9	0	87.8	4.9	23.0
2:00	16.2	55	115	11.9	0	87.8	5.7	25.4
3:00	16.2	54	93	10	0	87.9	5.2	23.8
4:00	16	57	102	9.7	0	87.8	5.1	23.5
5:00	16.2	56	110	9	0	87.8	4.9	22.8
6:00	16.1	56	116	7.9	0	87.8	4.6	21.9
7:00	16.2	60	95	6.2	0	87.7	4.2	20.4
8:00	16.8	62	84	5.4	0	87.6	4.0	19.6
9:00	17.2	60	70	5.5	0	87.5	4.0	19.6
10:00	17.5	65	95	10.7	0	87.3	5.0	23.2
11:00	17.3	66	80	10.6	0	87.2	4.9	22.7
12:00	17.9	64	112	10	0	87.1	4.7	22.0
13:00	18.7	62	101	9.7	0	87.1	4.6	21.8
14:00	18	65	86	12	0	87.0	5.1	23.5
15:00	17.5	69	79	8.4	0	86.8	4.1	20.2
16:00	16.6	72	98	10.2	0	86.5	4.3	21.0
17:00	16.4	72	101	11.9	0	86.3	4.6	21.8
18:00	15.8	74	106	12.9	0	86.0	4.6	22.0
19:00	15.5	78	77	6	0	85.7	3.1	16.5
20:00	15.2	81	103	6.1	0	85.3	3.0	15.9
21:00	14.3	90	110	8.5	0	84.5	3.0	16.1
22:00	14.4	89	97	6.2	0	83.9	2.5	13.8
23:00	14	90	97	4.9	0	83.4	2.2	12.4
During sampling								
Average	17.0	66.8	91.1	9.2	0.0	86.9	4.4	21.1
Median	17.2	65.0	95.0	10.0	0.0	87.1	4.6	21.8
Min	15.5	60.0	70.0	5.4	0.0	85.7	3.1	16.5
Max	18.7	78.0	112.0	12.9	0.0	87.7	5.1	23.5

Table 24. Hourly fire weather observations for Bottle Lake Forest on 19 March 2009 (Source: NRFA) (Shaded area was the sampling period).

Time (NZST)	**Temp** (ºC)	**RH** (%)	**Wind dir** (degrees)	**Wind spd** (km/h)	**Rain** (mm)	**FFMC**	**ISI**	**FWI**
0:00	12.5	76	356	0.6	0	83.6	1.8	4.4
1:00	12.6	75	0	1.2	0	83.6	1.9	4.5
2:00	12	83	314	0	0	83.5	1.7	4.1
3:00	12.2	80	339	3.2	0	83.4	2.0	4.8
4:00	11.8	83	254	1.6	0	83.2	1.8	4.4
5:00	11.2	86	353	3.1	0	82.9	1.9	4.6
6:00	12.1	82	340	2.5	0	82.9	1.8	4.4
7:00	14.7	72	349	3	0	82.9	1.9	4.5
8:00	14.4	80	207	0.8	0	82.9	1.7	4.0
9:00	19.9	55	314	2.8	0	83.3	1.9	4.7
10:00	24.3	36	287	7.3	0	84.5	2.8	6.8
11:00	25.4	32	281	7.7	0	85.7	3.4	8.1
12:00	26.4	31	287	6.6	0	86.8	3.8	8.8
13:00	25	39	227	9.6	0	87.4	4.8	11.6
14:00	24.8	43	255	7.9	0	87.7	4.6	11.3
15:00	23.4	43	300	6.1	0	88.0	4.4	10.8
16:00	22.1	51	40	3.3	0	88.0	3.8	9.7
17:00	17.8	62	339	3.7	0	87.9	3.8	9.7
18:00	15.9	67	354	4.5	0	87.7	3.8	9.7
19:00	14.2	73	340	3.6	0	87.3	3.5	9.0
20:00	13.4	73	355	4.7	0	86.9	3.5	9.0
21:00	13.4	73	47	4	0	86.7	3.2	8.4
22:00	13.3	75	46	2.2	0	86.4	2.8	7.5
23:00	13.4	73	78	3.6	0	86.1	3.0	7.8
During sampling								
Average	20.6	52.6	275.4	5.1	0.0	86.2	3.4	8.4
Median	22.1	51.0	287.0	4.5	0.0	87.3	3.8	9.0
Min	14.2	31.0	40.0	0.8	0.0	82.9	1.7	4.0
Max	26.4	80.0	354.0	9.6	0.0	88.0	4.8	11.6

McLeans Island Forest

Table 25. Hourly fire weather observations for McLeans Island Forest on 23 January 2009 (Source: NIWA) (Shaded area was the sampling period).

Time (NZST)	**Temp** (ºC)	**RH** (%)	**Wind dir** (degrees)	**Wind spd** (km/h)	**Rain** (mm)	**FFMC**	**ISI**	**FWI**
0:00	16	94	50	9.3	0	84.3	3.1	10.6
1:00	17	94	50	13	0	83.3	3.2	11.0
2:00	16.4	93.9	60	13	0	82.4	2.9	10.1
3:00	16	93	50	9.3	0	81.8	2.2	8.1
4:00	16	92	70	5.6	0	81.4	1.8	6.5
5:00	15.8	93.2	50	7.4	0	81.0	1.8	6.8
6:00	16	92	80	11.1	0	80.7	2.1	7.8
7:00	16	89	40	5.6	0	80.6	1.6	6.0
8:00	17.6	85.8	30	13	0	80.6	2.3	8.4
9:00	20	69	80	7.4	0	81.0	1.8	6.8
10:00	23	55	90	5.6	0	81.8	1.8	6.8
11:00	25.6	39	80	14.8	0	83.3	3.6	12.0
12:00	27	33	80	18.5	0	85.0	5.4	17.3
13:00	28	30	70	20.4	0	86.7	7.5	21.9
14:00	27.2	32.9	70	24.1	0	87.8	10.6	27.9
15:00	27	33	80	22.2	0	88.7	10.9	28.5
16:00	27	33	70	24.1	0	89.4	13.2	32.5
17:00	26.1	34.9	70	20.4	0	89.8	11.6	29.8
18:00	26	41	70	16.7	0	89.9	9.8	26.4
19:00	24	51	60	16.7	0	89.8	9.7	26.3
20:00	20.4	68.1	30	9.3	0	89.3	6.2	19.1
21:00	18	80	350	3.7	0	88.5	4.2	14.2
22:00	16	87	10	3.7	0	87.5	3.6	12.7
23:00	15.8	90.8	330	3.7	0	86.5	3.1	11.3
During sampling								
Average	24.2	48.2	68.5	16.1	0.0	85.7	6.9	19.3
Median	26.0	39.0	70.0	16.7	0.0	86.7	7.5	21.9
Min	16.0	30.0	30.0	5.6	0.0	80.6	1.6	6.0
Max	28.0	89.0	90.0	24.1	0.0	89.9	13.2	32.5

Table 26. Hourly fire weather observations for McLeans Island Forest on 3 February 2009 (Source: NIWA) (Shaded area was the sampling period).

Time (NZST)	**Temp** (ºC)	**RH** (%)	**Wind dir** (degrees)	**Wind spd** (km/h)	**Rain** (mm)	**FFMC**	**ISI**	**FWI**
0:00	15	75	50	5.7	0	80.9	2.4	11.6
1:00	14	79	50	22.2	0	80.9	2.4	11.6
2:00	14	78.9	60	24.1	0	80.9	2.4	11.5
3:00	14	78	60	22.2	0	80.7	2.4	11.3
4:00	15	77	60	22.2	0	80.5	2.1	10.3
5:00	13.9	79	70	18.5	0	80.3	1.9	9.4
6:00	14	81	60	18.5	0	80.2	1.7	8.5
7:00	15	78	60	11.1	0	80.2	1.9	9.3
8:00	17	66.9	80	22.2	0	80.5	1.9	9.5
9:00	18	63	90	24.1	0	80.9	2.6	12.4
10:00	19	62	90	24.1	0	81.4	3.1	14.0
11:00	19.8	62	90	25.9	0	81.8	2.2	10.8
12:00	21	60	80	27.8	0	82.6	2.2	11.0
13:00	21	59	90	27.8	0	83.4	2.5	11.9
14:00	21.6	58.1	80	29.7	0	84.1	3.6	16.0
15:00	21	60	80	29.7	0	84.9	4.4	18.5
16:00	21	59	80	27.8	0	85.6	4.8	19.8
17:00	20.5	58.9	70	27.8	0	85.8	6.0	23.1
18:00	20	65	80	24.1	0	85.8	5.5	21.8
19:00	18	73	90	24.1	0	85.8	5.0	20.3
20:00	16.9	79.9	80	18.5	0	85.5	3.0	13.9
21:00	16	84	110	9.3	0	85.2	2.9	13.5
22:00	16	86	250	5.6	0	84.6	3.8	16.7
23:00	15.6	86.2	280	7.4	0	83.9	2.9	13.5
During sampling								
Average	18.6	57.7	66.2	12.8	0.0	83.3	3.5	15.3
Median	19.0	59.0	70.0	14.8	0.0	83.4	3.1	14.0
Min	11.0	43.0	30.0	7.4	0.0	80.2	1.9	9.3
Max	22.0	81.0	90.0	18.5	0.0	85.8	6.0	23.1

5.3 Actual fuel moisture content

Table 27. Average moisture content (n = 5) and weather observations under the canopy from Bottle Lake Forest on 19 March 2009.

Time		Moisture content						Pyschrometer		Windsonic 1m	
(DST)	(NZST)	Elevated	Surface	Loose	Compact	Soil (0-10 cm)	Soil (10-20 cm)	RH (%)	Temp (ºC)	Direction (degrees)	Speed (km/h)
8:00	7:00										
9:00	8:00										
10:00	9:00	17.96	28.33					55.1	19.4		
11:00	10:00	15.92	26.08					57.1	19.9		
12:00	11:00	15.16	26.75	158.65	104.15	3.42	1.98	43.7	21.7	257	1.44
13:00	12:00	12.8	24.62					40.7	22.6	245	1.8
14:00	13:00	12.95	24.35					45.7	21.9	170	1.44
15:00	14:00	14.14	22.43					53.9	20.6	201	1.44
16:00	15:00	15.22	28.13	152.84	93.1	2.29	1.29	61	18.8	292	1.08
17:00	16:00	12.92	20.65					66.9	17.1	304	1.44
18:00	17:00	12.13	20.86					63.3	16.2	314	1.44
19:00	18:00	13.89	22.28					66.5	15.3	343	1.08
20:00	19:00										
Average		14.31	24.45					55.4	19.3	266	1.4
Median		14.01	24.49					56.1	19.6	275	1.4
Min		12.13	20.65					40.7	15.3	170	1.1
Max		17.96	28.33					66.9	22.6	343	1.8

Table 28. Average moisture content (n = 5) and weather observations under the canopy from Bottle Lake Forest on 10 February 2009.

Time		Moisture content						Pyschrometer		Windsonic 1m	
(DST)	(NZST)	Elevated	Surface	Loose	Compact	Soil (0-10 cm)	Soil (10-20 cm)	RH (%)	Temp (ºC)	Direction (degrees)	Speed (km/h)
8:00	7:00	16.74	18.71	31.77	19.42	2.44	2.48	62.6	16	139	0.72
9:00	8:00	16.81	18.4					65	16.1	7	0.72
10:00	9:00	16.76	18.23					64.5	16	94	1.08
11:00	10:00	16.59	18.35					71.1	15.9	161	1.08
12:00	11:00	17.27	18.55	29.04	19.92	1.99	2.96	70.2	15.9	70	1.08
13:00	12:00	17.5	17.13					65.8	16.5	242	1.08
14:00	13:00	17.25	16.99					64.6	17.1	348	1.08
15:00	14:00	17.77	18.19					68.5	16.6	334	1.08
16:00	15:00	18.37	19.42	31.11	28.78	3.23	2.93	72.6	16.1	215	1.08
17:00	16:00	18.81	18.43					72.4	15.9	356	0.72
18:00	17:00	19.86	19.02					77.3	15.3	200	1.08
19:00	18:00										
20:00	19:00										
Average		17.61	18.31					68.6	16.1	252	1.0
Median		17.27	18.4					68.5	16	242	1.1
Min		16.59	16.99					62.6	15.3	70	0.7
Max		19.86	19.42					77.3	17.1	356	1.1

Table 29. Average moisture content (n = 5) and weather observations under the canopy from McLeans Island forest on 23 January 2009.

Time		Moisture content						Pyschrometer		Windsonic 1m	
(DST)	(NZST)	Elevated	Surface	Loose	Compact	Soil (0-10 cm)	Soil (10-20 cm)	RH (%)	Temp (ºC)	Direction (degrees)	Speed (km/h)
8:00	7:00	33.6	25.45	65.31	46.87	3.42	2.56	94.9	15.1	47	1.08
9:00	8:00	29.65	25.32					87.3	16.4	332	1.44
10:00	9:00	22.16	23.57					74.9	19.4	289	1.08
11:00	10:00	15.04	19.31					46.1	23.5	61	1.44
12:00	11:00	10.88	18.18	25.07	40.87	3.79	2.85	39.8	25.9	24	1.80
13:00	12:00	10.67	14.08					29.6	27.8	51	2.16
14:00	13:00	10.59	12.26					25.2	28.3	35	2.16
15:00	14:00	9.68	14.55					29	28.6	45	1.80
16:00	15:00	9.91	14.05	20.6	17.78	4.79	3.3	32.2	27.3	38	2.16
17:00	16:00	8.33	10.56					30.9	26.9	15	2.16
18:00	17:00	9.34	13.57					33.7	26.7	26	1.80
19:00	18:00	9.56	12.57					38.5	26.0	65	1.44
20:00	19:00	12.25	14.16	18.12	18.41	3.64	2.32	51.3	23.8	12	1.44
Average		14.74	16.74					47.2	24.3	80	1.7
Median		10.67	14.16					38.5	26	45	1.8
Min		8.33	10.56					25.2	15.1	12	1.1
Max		33.6	25.45					94.9	28.6	332	2.2

Table 30. Average moisture content (n = 5) and weather observations under the canopy from McLeans Island forest on 3 February 2009.

Time		Moisture content						Pyschrometer		Windsonic 1m	
(DST)	(NZST)	Elevated	Surface	Loose	Compact	Soil (0-10 cm)	Soil (10-20 cm)	RH (%)	Temp (ºC)	Direction (degrees)	Speed (km/h)
8:00	7:00	26.5	19.56	25.09	23.65	2.16	1.53	78.7	10.8	324	1.08
9:00	8:00	18.1	16.84					72.4	12.9	342	1.44
10:00	9:00	17.18	16.46					65.3	15.5	93	1.08
11:00	10:00	16.14	16.31					59.1	17	344	1.44
12:00	11:00	15.5	16.12	18.05	15.88	1.72	1.55	54.45	18.9	318	1.44
13:00	12:00	14.85	15.29					49.35	19.9	117	1.44
14:00	13:00	12.66	13.98					41.35	21.9	343	1.44
15:00	14:00	12.5	13.58					43.65	21.9	30	1.44
16:00	15:00	12.29	13.77	13.98	10.46	3.08	2.53	42.8	22.2	62	1.8
17:00	16:00	12.58	12.88					44.75	21.2	6	1.8
18:00	17:00	13.36	12.58					50	20.7	346	1.8
19:00	18:00	13.07	13.53					54.8	19.9	335	1.8
20:00	19:00	14.8	14.64	17.82	15.69	2.11	1.63	64.55	17.4	354	1.08
Average		15.35	15.04					55.48	18.47	232	1.5
Median		14.8	14.64					54.45	19.85	324	1.4
Min		12.29	12.58					41.35	10.8	6	1.1
Max		26.5	19.56					78.7	22.2	354	1.8

5.4 Actual (sampled) fuel moisture content time-series

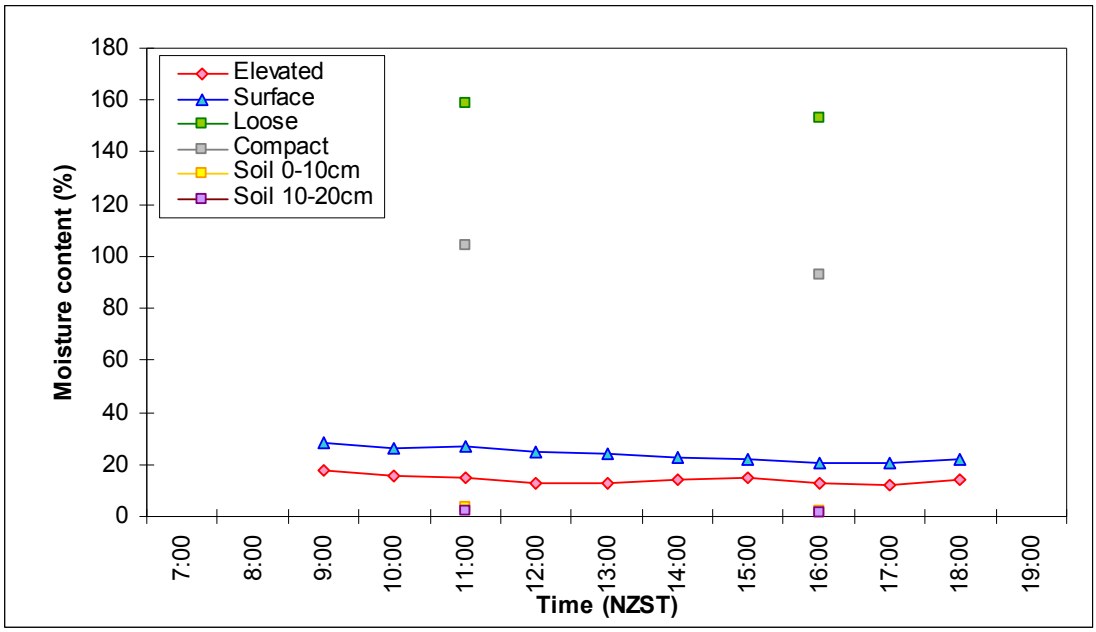


Figure 53. Average fuel moisture content from Bottle Lake Forest on 19 March 2009.

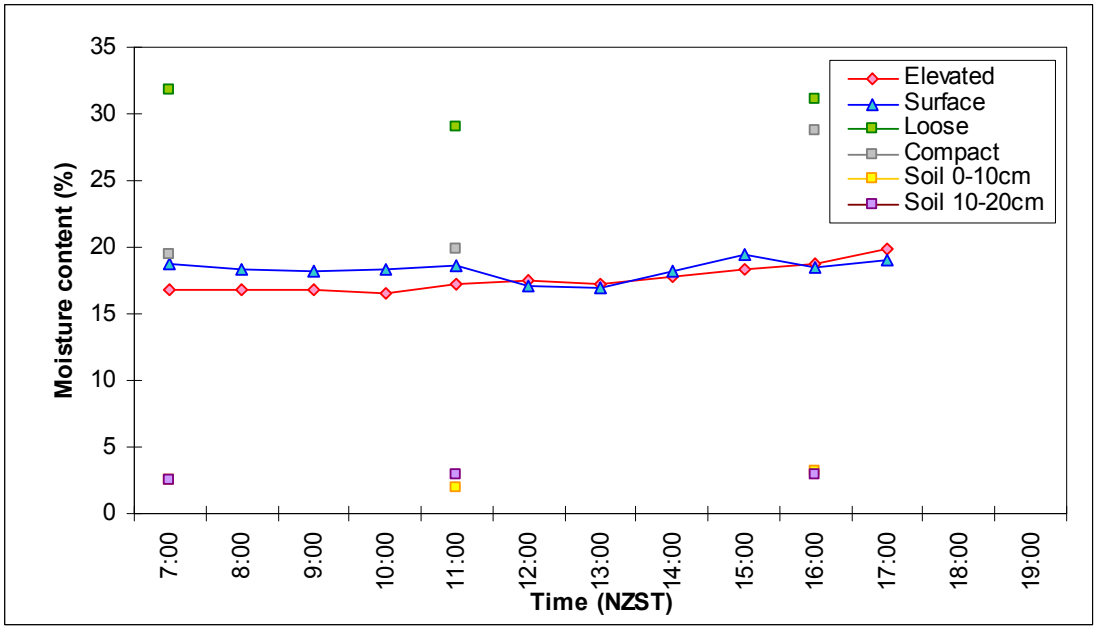


Figure 54. Average fuel moisture content from Bottle Lake Forest on 10 February 2009.

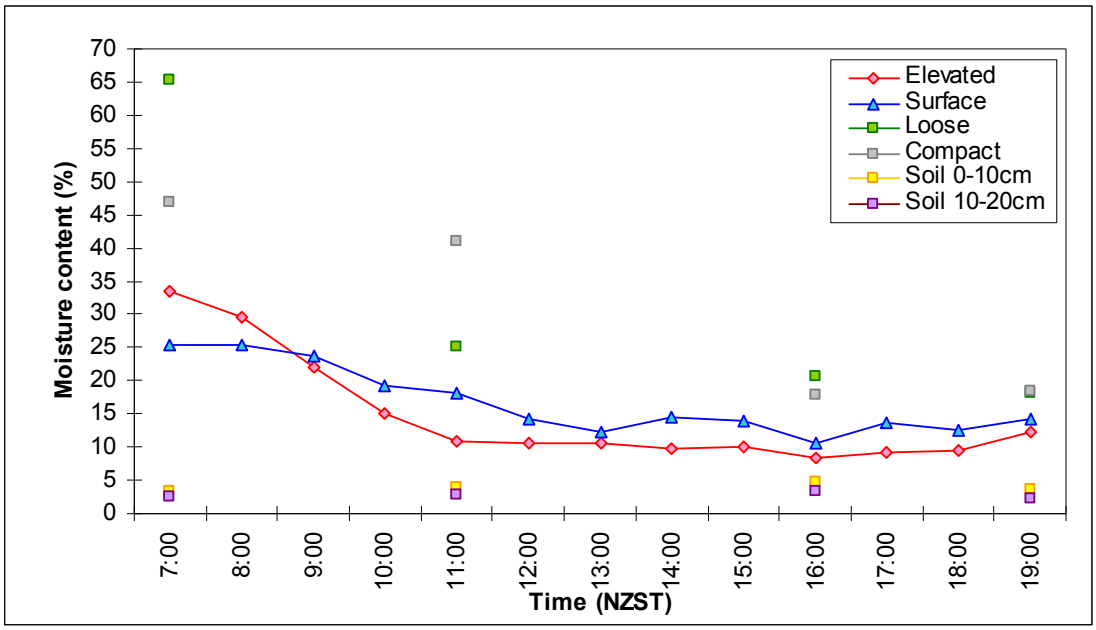


Figure 55. Average fuel moisture content from McLeans Island Forest on 23 January 2009.

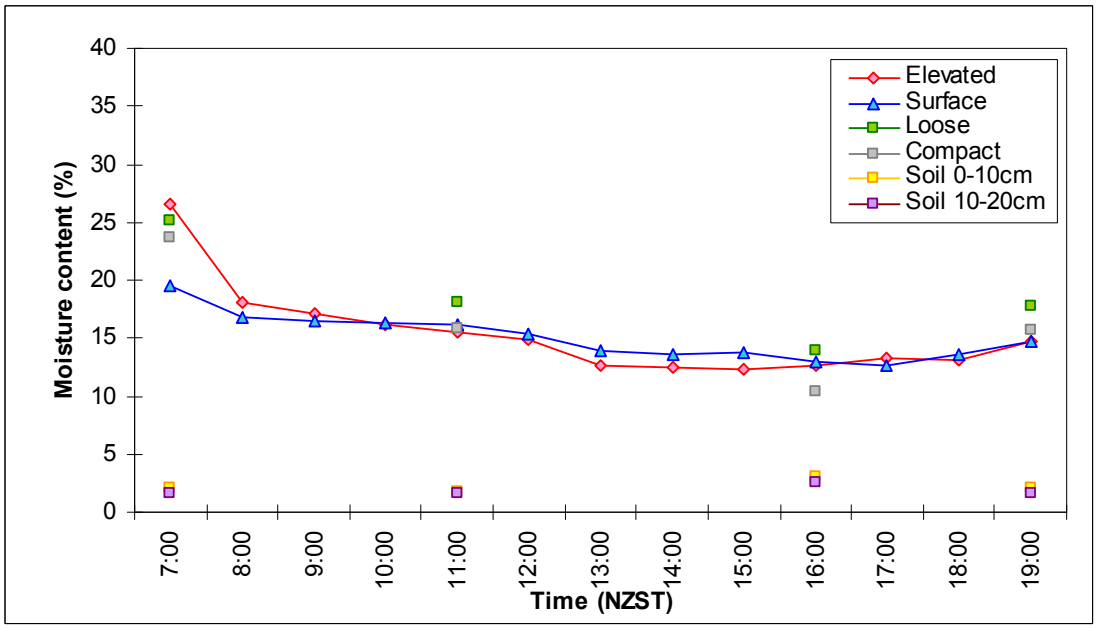


Figure 56. Average fuel moisture content from McLeans Island Forest on 3 February 2009.

5.5 Time-series of actual and predicted fuel moisture content

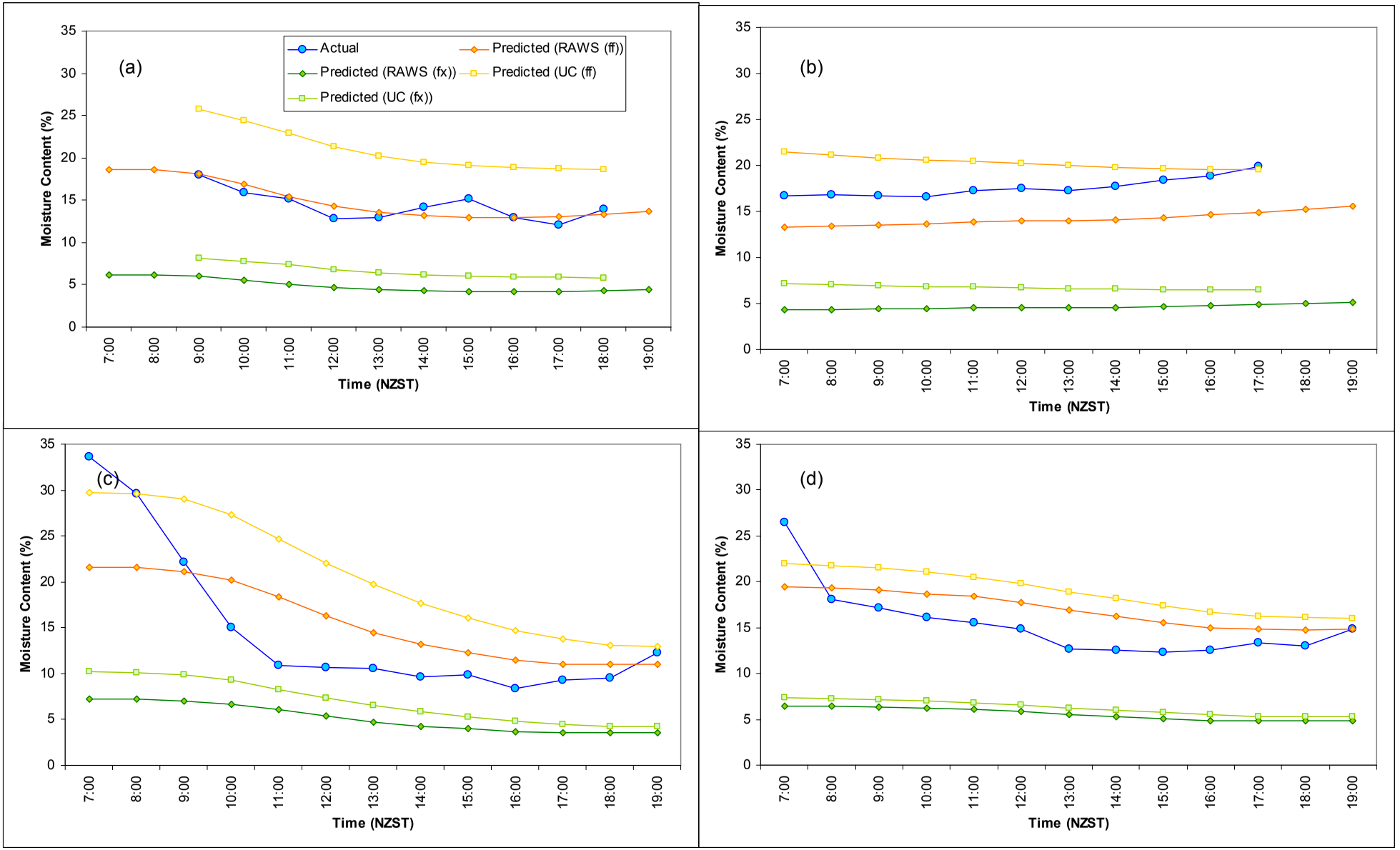


Figure 57. Actual versus predicted elevated moisture content calculated using weather observations from the nearest RAWS or under the canopy (UC): (a) Bottle Lake Forest 19 March 2009; (b) Bottle Lake Forest 10 February 2009; (c) McLeans Forest 23 January 2009; (d) McLeans Forest 3 February 2009. Fuel moisture predicted using both the FF- and FX- scales of the FFMC.

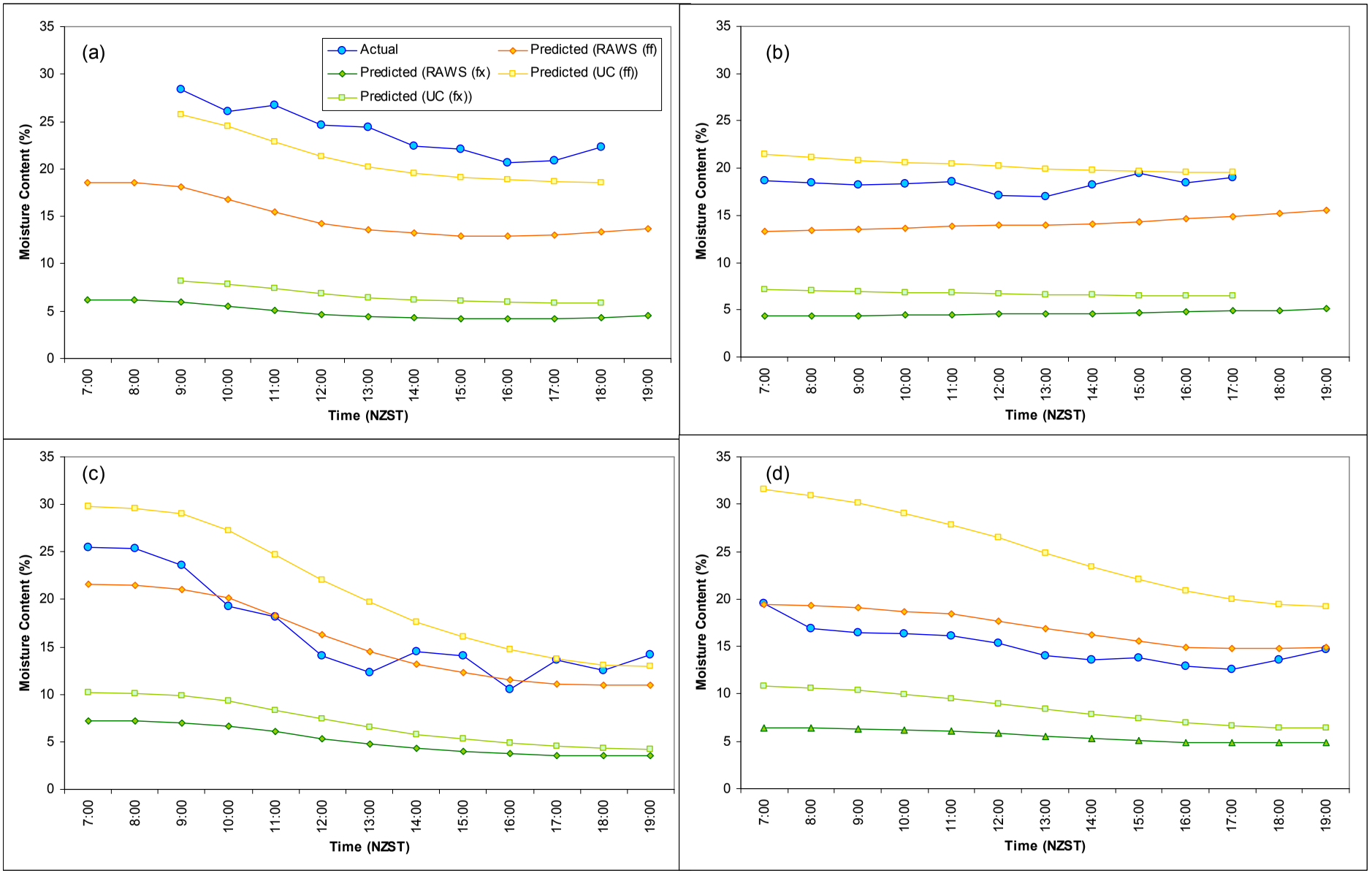


Figure 58. Actual versus predicted surface moisture content calculated using weather observations from the nearest RAWS or under the canopy (UC): (a) Bottle Lake Forest 19 March 2009; (b) Bottle Lake Forest 10 February 2009; (c) McLeans Forest 23 January 2009; (d) McLeans Forest 3 February 2009. Fuel moisture predicted using both the FF- and FX- scales of the FFMC.

5.6 Actual versus predicted moisture content

Elevated Layer

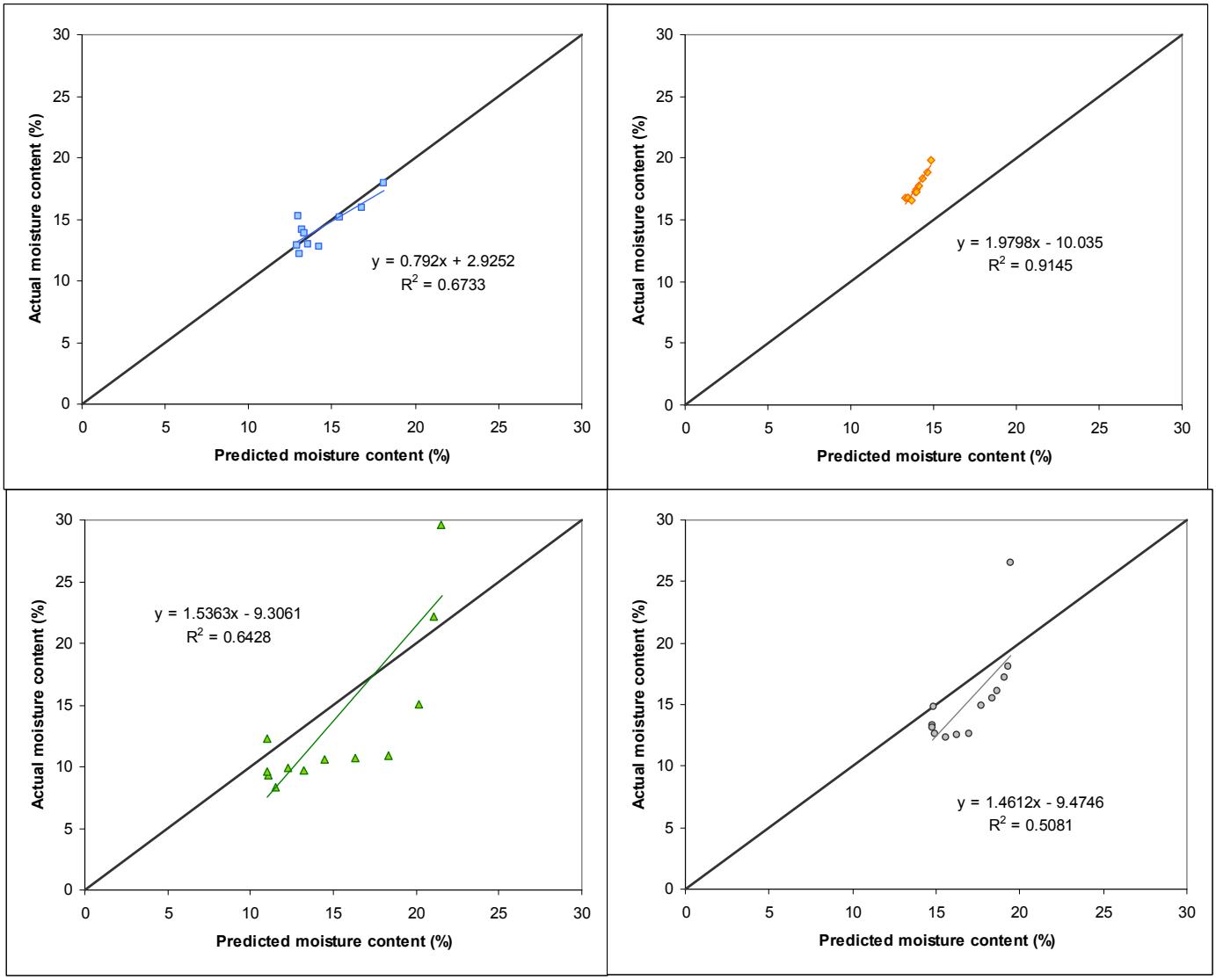


Figure 59. Actual versus predicted elevated moisture content calculated using RAWS weather: (a) Bottle Lake Forest 19 March 2009; (b) Bottle Lake Forest 10 February 2009; (c) McLeans Forest 23 January 2009; (d) McLeans Forest 3 February 2009. Fuel moisture content predicted using the FF-scale of the FFMC.

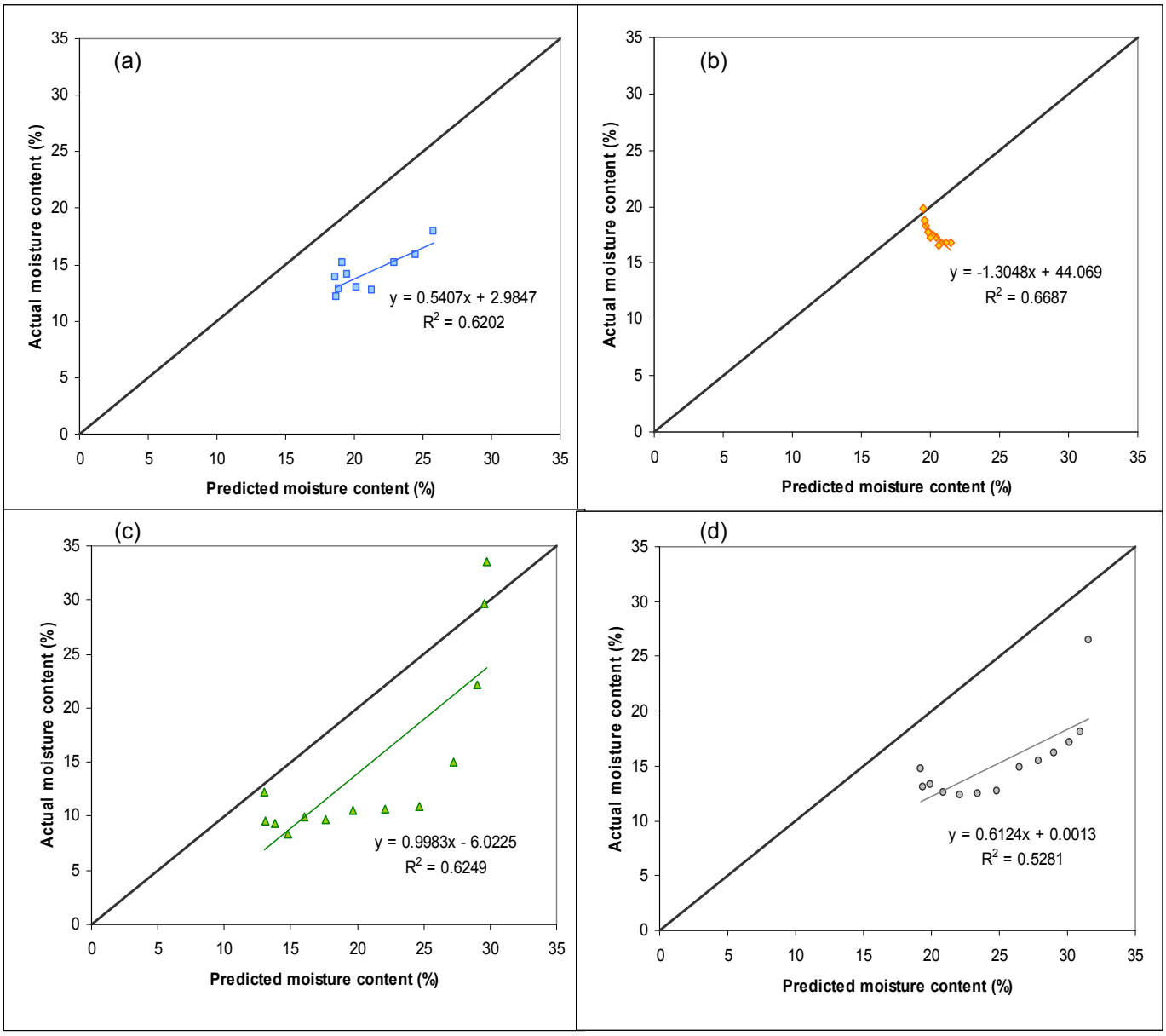


Figure 60. Actual versus predicted elevated moisture content calculated using under-canopy weather: (a) Bottle Lake Forest 19 March 2009; (b) Bottle Lake Forest 10 February 2009; (c) McLeans Forest 23 January 2009; (d) McLeans Forest 3 February 2009. Fuel moisture content predicted using the FF-scale of the FFMC.

Surface Layer

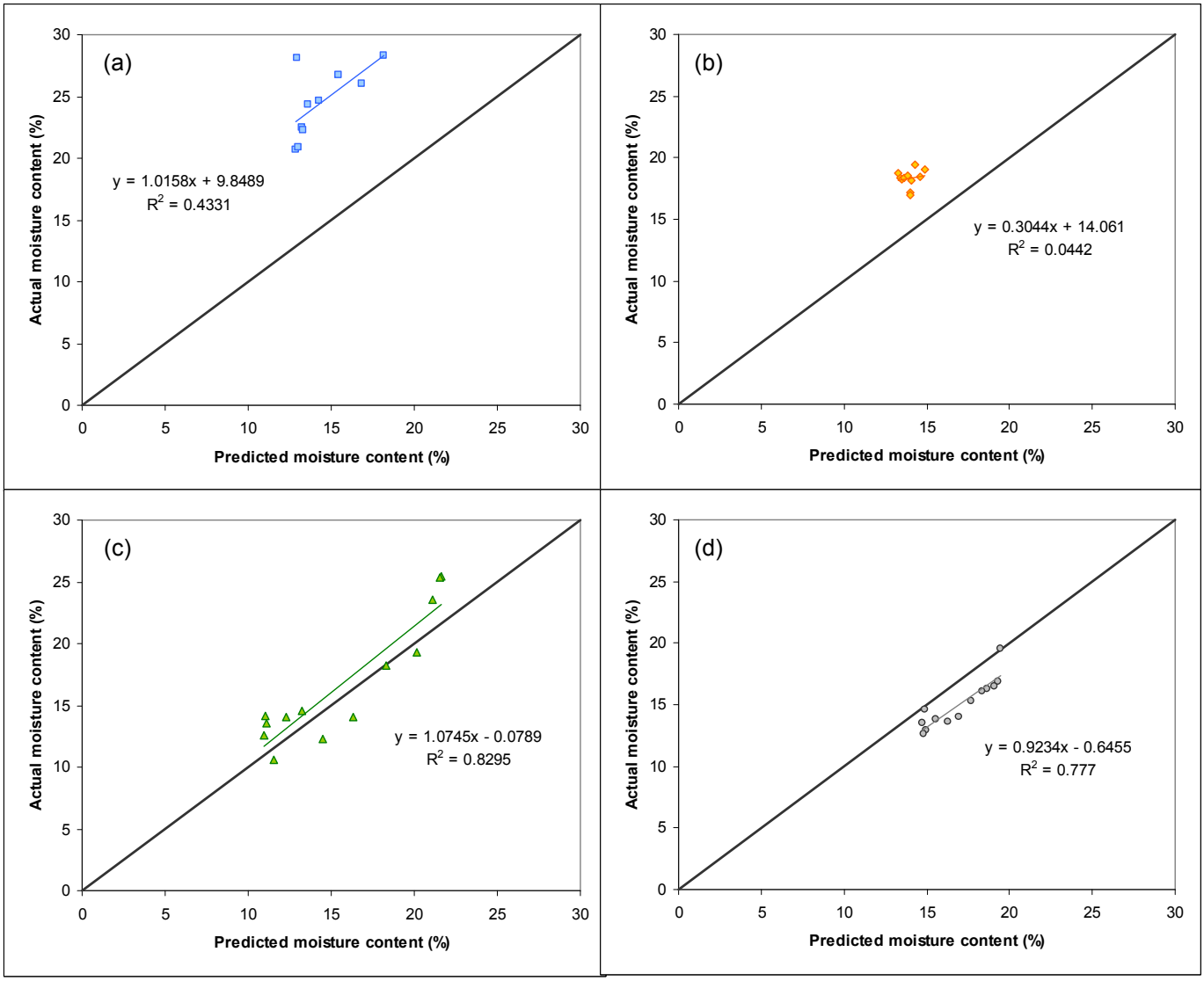


Figure 61. Actual versus predicted surface moisture content calculated using RAWS weather: (a) Bottle Lake Forest 19 March 2009; (b) Bottle Lake Forest 10 February 2009; (c) McLeans Forest 23 January 2009; (d) McLeans Forest 3 February 2009. Fuel moisture content predicted using the FF-scale of the FFMC.

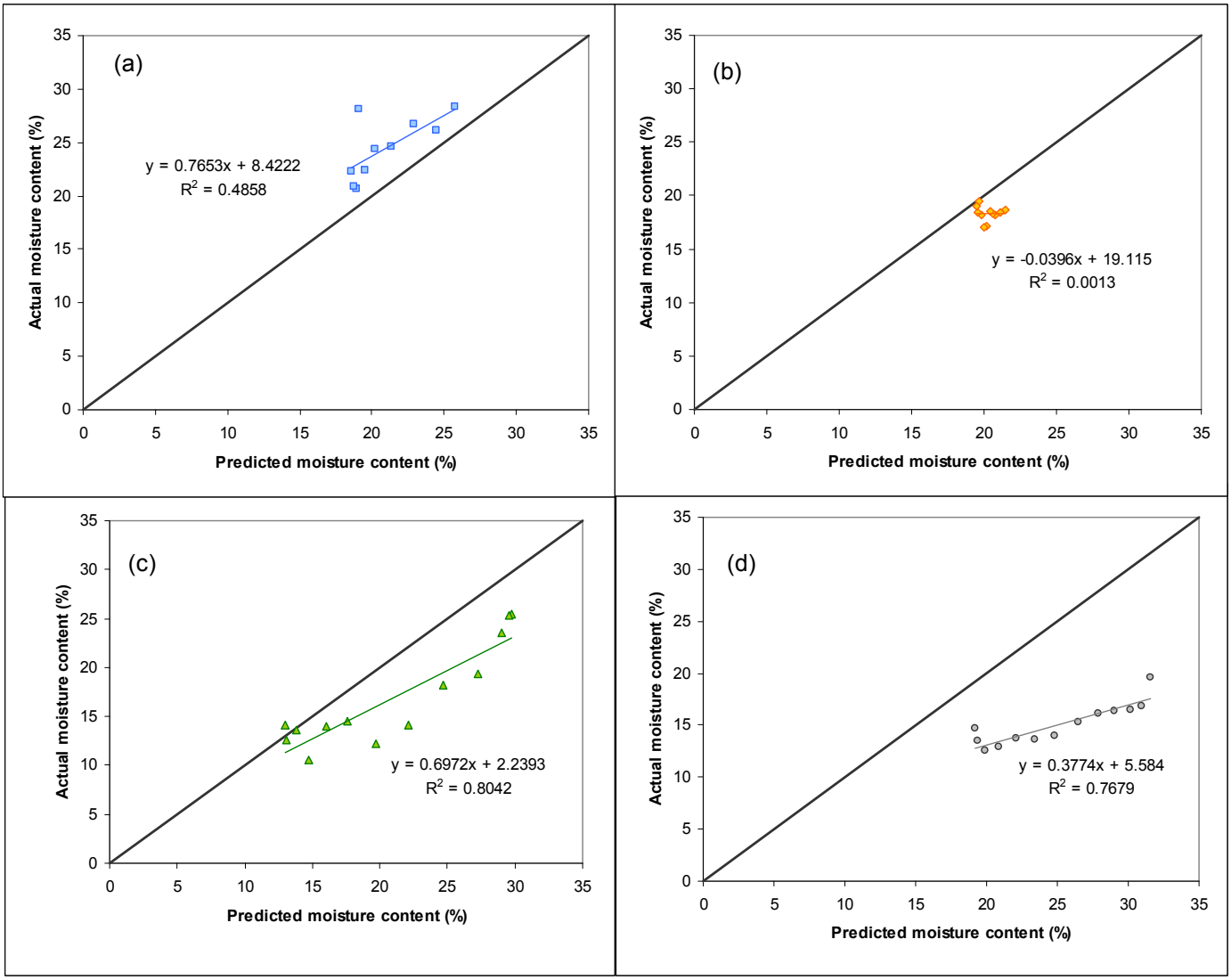


Figure 62. Actual versus predicted surface moisture content calculated using under-canopy weather: (a) Bottle Lake Forest 19 March 2009; (b) Bottle Lake Forest 10 February 2009; (c) McLeans Forest 23 January 2009; (d) McLeans Forest 3 February 2009. Fuel moisture content predicted using the FF-scale of the FFMC.

Table 31. Statistical comparison of elevated moisture content calculated from: RAWS or under the canopy weather observations.

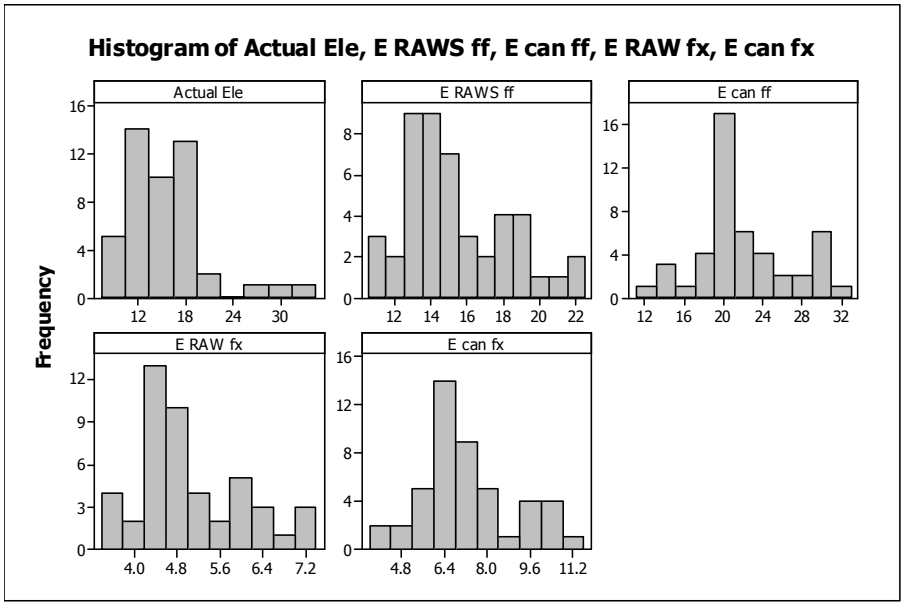
Station name		RAWS		Under-canopy	
		FFMC (FF-scale)	**FFMC** (FX-scale)	**FFMC** (FF-scale)	**FFMC** (FX-scale)
Bottle Lake Forest, 19/03/2009	n	10	10	10	10
	RMSE	1.03	9.69	6.81	7.76
	ME	-0.06	9.61	-6.63	7.67
	R^2	0.67	0.67	0.62	0.59
Bottle Lake Forest, 10/02/2009	n	11	11	11	11
	RMSE	3.67	13.08	3.07	10.94
	ME	3.63	13.05	-2.67	10.88
	R^2	0.89	0.92	0.67	0.67
McLeans Island Forest, 23/01/2009	n	13	13	13	13
	RMSE	5.36	11.82	7.79	10.06
	ME	-0.91	9.60	-6.06	7.78
	R^2	0.64	0.65	0.62	0.63
McLeans Island Forest, 3/02/2009	n	13	13	13	13
	RMSE	3.18	10.29	10.18	7.42
	ME	-1.64	9.76	-9.71	6.89
	R^2	0.51	0.51	0.53	0.54

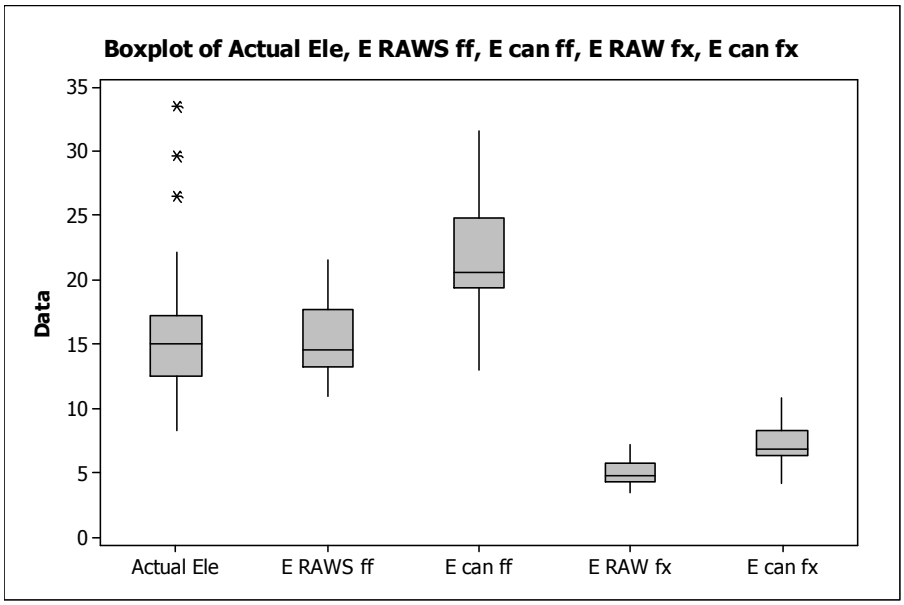
Table 32. Statistical comparison of surface moisture content calculated from: RAWS or under the canopy weather observations.

Station name		RAWS		Under-canopy	
		FFMC (FF-scale)	**FFMC** (FX-scale)	**FFMC** (FF-scale)	**FFMC** (FX-scale)
Bottle Lake Forest, 19/03/2009	n	10	10	10	10
	RMSE	10.28	19.89	4.05	17.94
	ME	10.08	19.75	3.51	17.81
	R^2	0.36	0.43	0.49	0.49
Bottle Lake Forest, 10/02/2009	n	11	11	11	11
	RMSE	4.39	13.77	2.18	11.60
	ME	4.33	13.75	-1.97	11.58
	R^2	0.05	0.05	0.00	0.00
McLeans Island Forest, 23/01/2009	n	13	13	13	13
	RMSE	2.33	12.16	4.99	10.25
	ME	1.09	11.59	-4.06	9.78
	R^2	0.83	0.83	0.80	0.81
McLeans Island Forest, 3/02/2009	n	13	13	13	13
	RMSE	2.15	9.55	10.42	6.64
	ME	-1.95	9.45	-10.02	6.58
	R^2	0.78	0.78	0.77	0.77

5.7 Data analysis:

Hourly elevated fuel moisture content





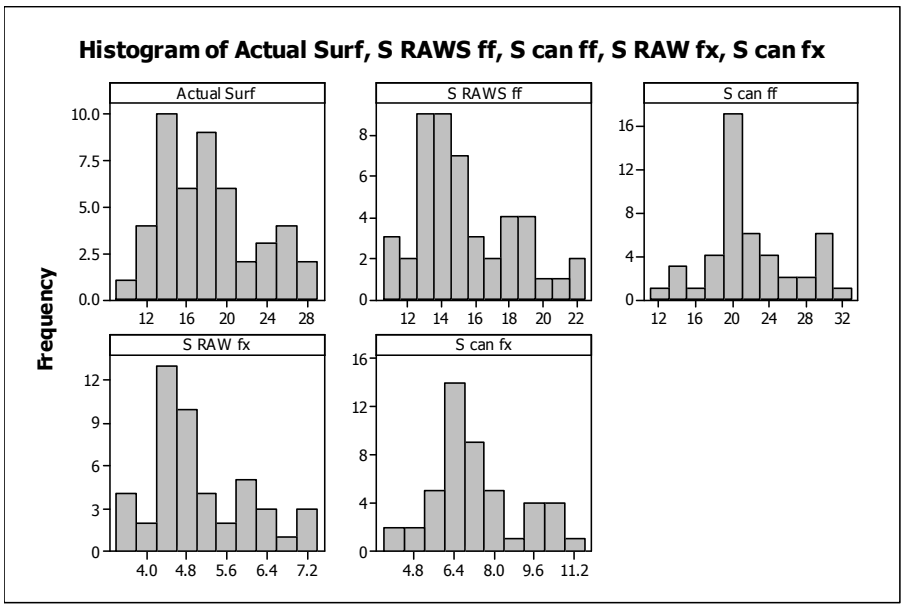
One-way ANOVA: Actual Ele, E RAWS ff, E can ff, E RAW fx, E can fx

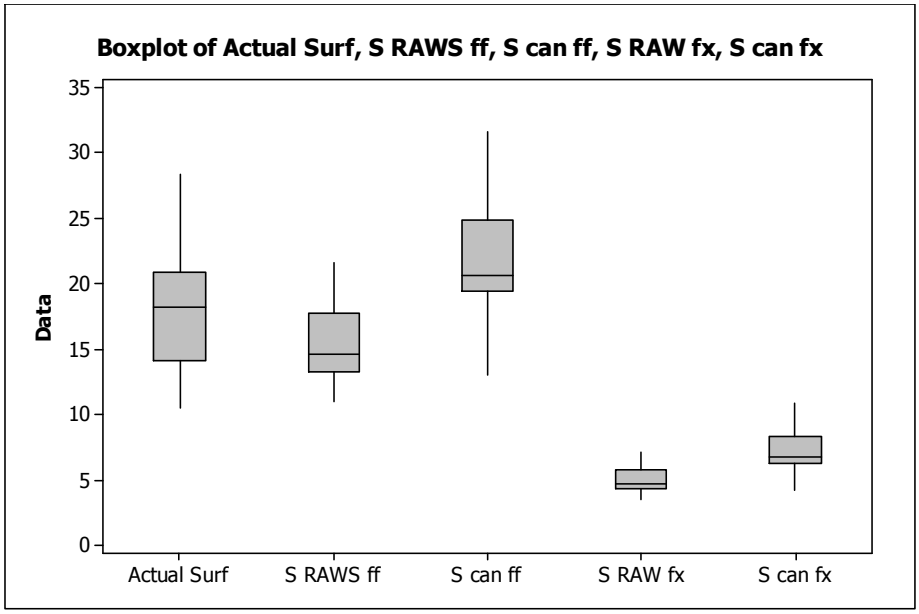
Source	DF	SS	MS	F	P
Factor	4	8794.8	2198.7	188.03	0.000
Error	230	2689.4	11.7		
Total	234	11484.3			

S = 3.420 R-Sq = 76.58% R-Sq(adj) = 76.17%

```
                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level         N    Mean  StDev  --+---------+---------+---------+-------
Actual Ele   47  15.489  4.939                      (-*-)
E RAWS ff    47  15.354  2.833                      (-*-)
E can ff     47  21.886  4.713                                  (-*-)
E RAW fx     47   5.036  0.973  (-*-)
E can fx     47   7.254  1.697       (-*)
                                  --+---------+---------+---------+-------
                                  5.0       10.0      15.0      20.0

Pooled StDev = 3.420


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons

Individual confidence level = 99.36%


Actual Ele subtracted from:

             Lower   Center   Upper  ---------+---------+---------+---------
E RAWS ff   -2.075   -0.135   1.806                    (-*-)
E can ff     4.456    6.396   8.337                           (-*-)
E RAW fx   -12.393  -10.453  -8.512          (-*)
E can fx   -10.175   -8.235  -6.295            (-*-)
                                  ---------+---------+---------+---------
                                         -10         0        10
```

Hourly surface fuel moisture content





One-way ANOVA: Actual Surf, S RAWS ff, S can ff, S RAW fx, S can fx

```
Source   DF       SS      MS       F      P
Factor    4   9738.8  2434.7  219.14  0.000
Error   230   2555.3    11.1
Total   234  12294.1

S = 3.333   R-Sq = 79.22%   R-Sq(adj) = 78.85%
```

```
                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level         N    Mean  StDev  --+---------+---------+---------+-------
Actual Surf  47  18.278  4.635                            (-*)
S RAWS ff    47  15.354  2.833                       (-*-)
S can ff     47  21.886  4.713                                 (-*-)
S RAW fx     47   5.036  0.973  (-*-)
S can fx     47   7.254  1.697       (-*)
                                  --+---------+---------+---------+-------
                                  5.0      10.0      15.0      20.0

Pooled StDev = 3.333
```

```
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons

Individual confidence level = 99.36%
```

```
Actual Surf subtracted from:

             Lower   Center    Upper  ---------+---------+---------+--------
S RAWS ff   -4.815   -2.924   -1.032                (-*-)
S can ff     1.716    3.607    5.499                       (-*)
S RAW fx   -15.133  -13.242  -11.350      (-*-)
S can fx   -12.915  -11.024   -9.133        (-*-)
                                  ---------+---------+---------+--------
                                         -10         0        10
```