Spatial and Temporal Trends in Yield Map Data

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1. Introduction

As part of the research programme to develop precision farming management guidelines, started in 1995/96 on four sites in England, yield map data were recorded from 1995 onwards. Their trends were used as an input to assist in the development of management strategies, namely applying nitrogen based upon long term (historic) yield data (Welsh et al., 2001a and 2001b). This section gives the simplest analysis of this data showing the variation in yield both i) within the field (spatial), and ii) between years (temporal).

2. Methods

2.1. *Data collection and processing*

Yield map data were collected between 1995 and 2000 inclusive (Appendix A1). The variation in crop yields were recorded using a combine harvester equipped with a radiometric yield sensor, with a mean instantaneous grain flow error of 0.05 kg/s and a standard deviation of 0.15 kg/s. Both statistics are effectively independent of grain flow rate as shown in *Fig 1* (after Moore, 1998). When harvesting an 8 t/ha crop with a 5 m wide cutter bar at 1.25 m/s (4.5 km/h) this is equivalent to an instantaneous grain flow error of 1%.

Fig 1. Yield monitor calibration

The data were processed to remove identifiable errors using the methodology described in Blackmore and Moore (1999) and to extract:

(1) the spatial trends using techniques described by Blackmore (2000), and

(2) the inter-year offset where the whole field yielded high or low as a result of different weather patterns between the years.

2.2. *Spatial trend map*

The spatial trend map shows the trends of the spatial variability over a number of years. It was expected that some parts of the field would always produce higher than average yields while other parts of the field would always produce lower than average yields. Data for the spatial trend map were produced by calculating the mean yields, for the 6 years, over areas of 20m radius based on a 20m grid. The choice of the grid size is important as the larger the grid size the greater the smoothing effect on the final map. A grid size of 20m and a yield class of 1 ton per hectare was chosen to give the contours in the resulting map.

2.3. *Temporal stability: Inter-year offset*

It was noted that in some years there was a large difference between yields due to the climatic conditions, which should be separated out from the spatial effects. In this case to identify the effects a simple histogram was used.

3. Results

Yield data and the results of the analysis are presented here for four fields (Trent Field, Onion Field, Far Sweetbrier and Twelve Acres Field) over 6 years. Trent Field was planted with winter malting barley in each year between 1995 and 2000. Onion Field was planted with winter wheat each year. Far Sweetbrier was managed in a rotation of winter wheat (1993, 95, 96, 98 and 2000) and Oil Seed Rape (1994 and 97), however, due to the previous wet autumn, was planted with spring wheat in 1999. (All years here, denote the year of harvest.) Yield data from 1993 was included to replace 1997. Twelve Acres was planted with winter wheat. All fields had variable rate nitrogen strips interlaced with

standard nitrogen strips between 1997 and 2000 as part of the research programme. The data for the variable rate strips were deleted for this analysis.

3.1. *Spatial trend map*

The spatial trend maps, for both 3 and 6-year time periods, are presented in *Figs 2* and *3* respectively. The spatial trends identified in *Fig 2*, were used as a basis for spatially variable fertiliser treatment trials in 1998. (See Welsh et al., 2001a, and b) The contour of the mean yield over this time period is shown. It is interesting to note that although there is significant spatial variability in most individual years (not shown), the effects from each year appear to cancel out and the spatial trend map flattens out over time. The maps in *Fig 3* show only a $\pm$ 1 ton variance from the mean after 6 years.

Fig 2. The spatial trend maps for the four fields after three years.

3.2. *Temporal stability: Inter-year offset*

The inter-year offset only needs to be defined by the changing median but other inferences can be drawn from the data when a histogram is used. Most of the histograms are skewed towards the high yielding end of their distribution. The inter-year offset for the four fields can be seen in the histograms of *Fig 4*. 1996 seems to be a universally good year, while 1997 in Trent Field was particularly low yielding.

Fig 3. The spatial trend maps for the four fields after six years.

Statistical analysis of the data in *Fig 4* is presented in Table 1. This gives the mean yield and standard deviation for the four main fields in each of the harvest years. In addition to the above, the 95% confidence limits and coefficient of variation are shown

together with an estimate of the range expressed as a percentage of the mean. The average variation in yield for the 4 fields is ± 25% of their mean which range between ± 20% to ± 33% in the first three years, when uniform treatments were applied.

Table 1

Yield statistics for the four main field trial sites over 6 years

Fig 4. Six year yield histograms for the four fields

References

Blackmore B S; Moore M R (1999). Remedial Correction of Yield Map Data. Precision Agriculture Journal, Kluwer, **1**, 53-66

Blackmore B S (2000). The interpretation of trends from multiple yield maps. Computers and Electronics in Agriculture, Elsevier, **26**(1), pp.37-51

Earl R; Taylor J C; Wood G A; Bradley R I; James I T; Waine T; Welsh J P; Knight S; Godwin R J (2001) Soil factors and their influence on within-field crop variability I: Field observation of soil variation. Submitted to Precision Agriculture.

Moore M R (1998). An investigation into the accuracy of yield maps and their subsequent use in crop management. Unpublished PhD Thesis, Cranfield University at Silsoe

Welsh J P; Wood G A; Godwin R J; Taylor J C; Earl R; Blackmore S; Knight S (2001a) Developing Strategies for Spatially Variable Nitrogen Application in I: Winter Barley, Submitted to Precision Agriculture

Welsh J P; Wood G A; Godwin R J; Taylor J C; Earl R; Blackmore S; Knight S (2001b) Developing Strategies for Spatially Variable Nitrogen Application in II: Wheat, Submitted to Precision Agriculture, (2001b).

Appendix 1A.

Trent Field yield maps

Onion Field yield maps

Far Sweetbrier yield maps

Twelve acres field yield maps

Table 1
Yield statistics for the four main field trial sites over 6 years

FSB Year	Mean yield t ha^{-1}	Standard deviation t ha^{-1}	± 95% limits t ha^{-1}	Coefficient of variation	1.96 CV x 100%
1993	7.49	1.15	2.24	0.15	30
1995	8.75	0.89	1.74	0.10	20
1996	9.52	0.81	1.58	0.08	17
Mean, years 1-3	8.59	0.95	1.86	0.11	22
1998	7.70	1.05	2.06	0.14	27
1999	6.10	1.51	2.96	0.25	49
2000	7.00	1.21	2.38	0.17	34
Mean , years 4-6	6.93	1.26	2.46	0.19	36
Grand mean	7.64	1.27	2.50	0.18	29

Trent Year	Mean yield t ha^{-1}	Standard deviation t ha^{-1}	± 95% limits t ha^{-1}	Coefficient of variation	1.96 CV x 100%
1995	5.84	0.79	1.54	0.13	26
1996	7.25	1.04	2.03	0.14	28
1997	4.24	0.97	1.91	0.23	45
Mean, years 1-3	5.77	0.93	1.83	0.17	33
1998	7.43	0.96	1.88	0.13	25
1999	5.77	1.14	2.23	0.20	39
2000	7.01	1.40	2.74	0.20	39
Mean, years 4-6	6.74	1.17	2.28	0.18	34
Grand mean	6.25	1.05	2.05	0.17	34

12 acre Year	Mean yield t ha^{-1}	Standard deviation t ha^{-1}	± 95% limits t ha^{-1}	Coefficient of variation	1.96 CV x 100%
1995	4.88	0.67	1.31	0.14	27
1996	8.26	1.12	2.20	0.14	27
1997	0.00	0.00	0.00	0.00	0.00
Mean, years 1-3	6.57	0.89	1.75	0.14	27
1998	7.07	0.69	1.34	0.10	19
1999	7.34	0.80	1.56	0.11	21
2000	5.36	0.92	1.80	0.17	34
Mean, years 4-6	6.59	0.80	1.57	0.13	25
Grand mean	6.58	0.84	1.64	0.13	25

Onion Year	Mean yield t ha^{-1}	Standard deviation t ha^{-1}	± 95% limits t ha^{-1}	Coefficient of variation	1.96 CV x 100%
1995	8.25	0.90	1.77	0.11	21
1996	9.10	0.87	1.71	0.10	19
1997	6.28	1.39	2.73	0.22	20
Mean, years 1-3	7.98	0.81	1.60	0.10	20
1998	5.71	0.87	1.70	0.15	30
1999	6.13	1.18	2.30	0.19	38
2000	6.35	1.16	2.28	0.18	36
Mean, years 4-6	6.06	1.07	2.09	0.18	34
Grand mean	6.97	1.06	2.08	0.16	27

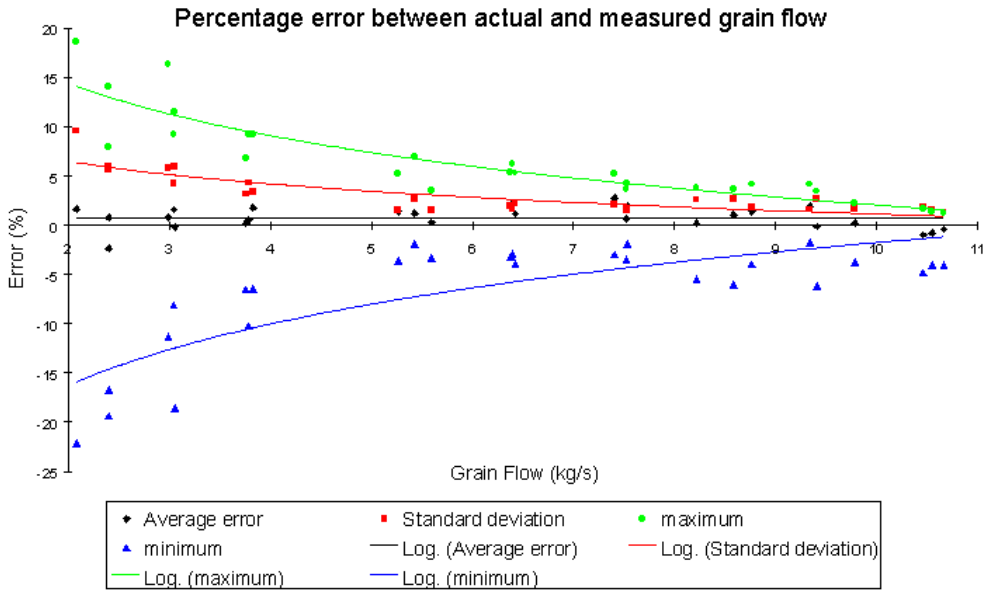


Fig 1. Yield monitor calibration

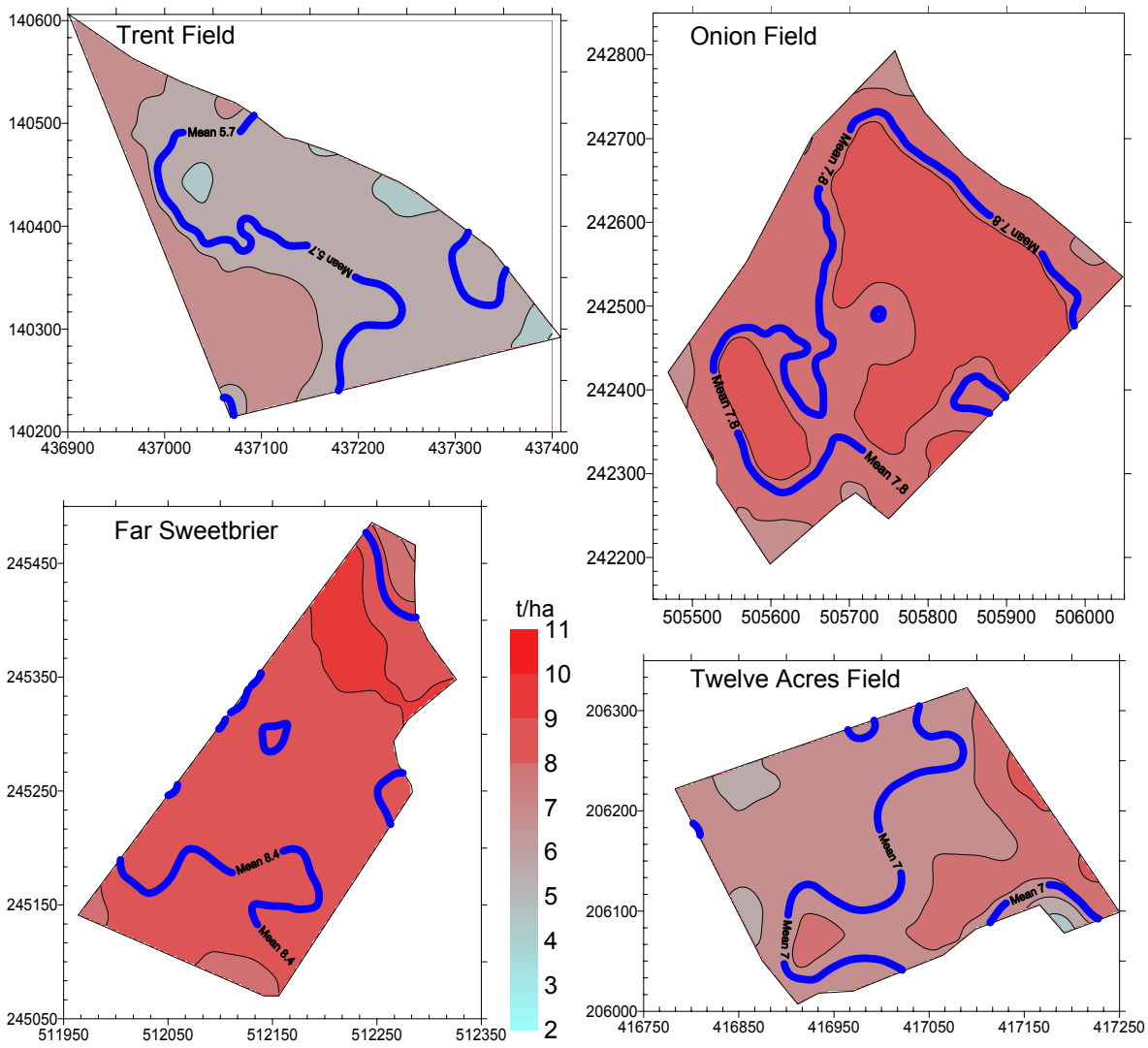


Fig 2. The spatial trend maps for the four fields after three years.

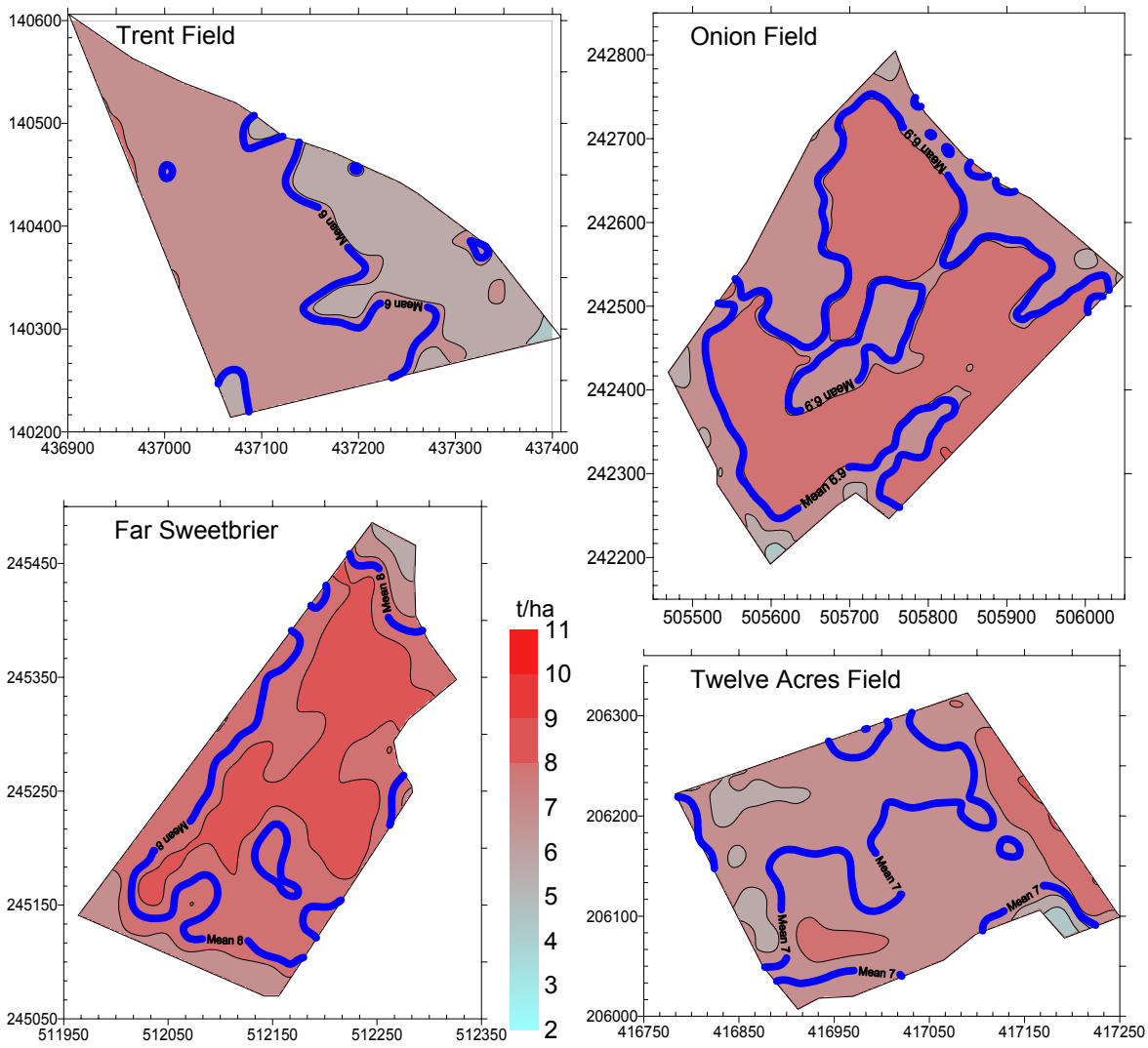


Fig 3. The spatial trend maps for the four fields after six years.

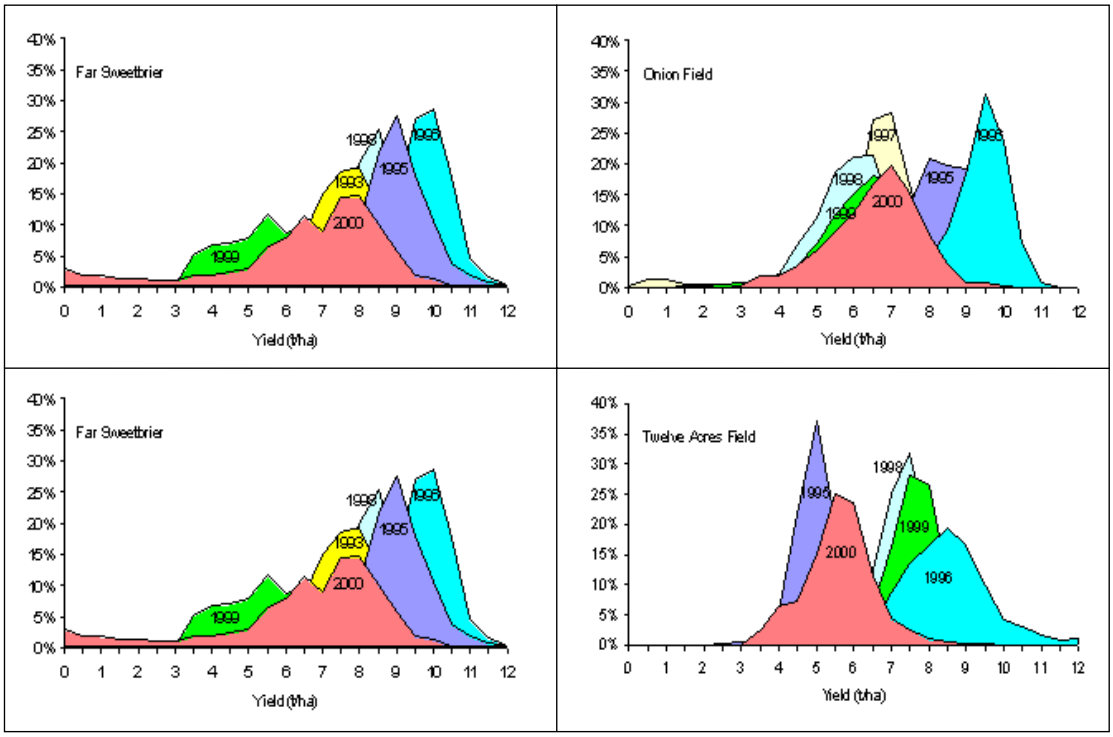
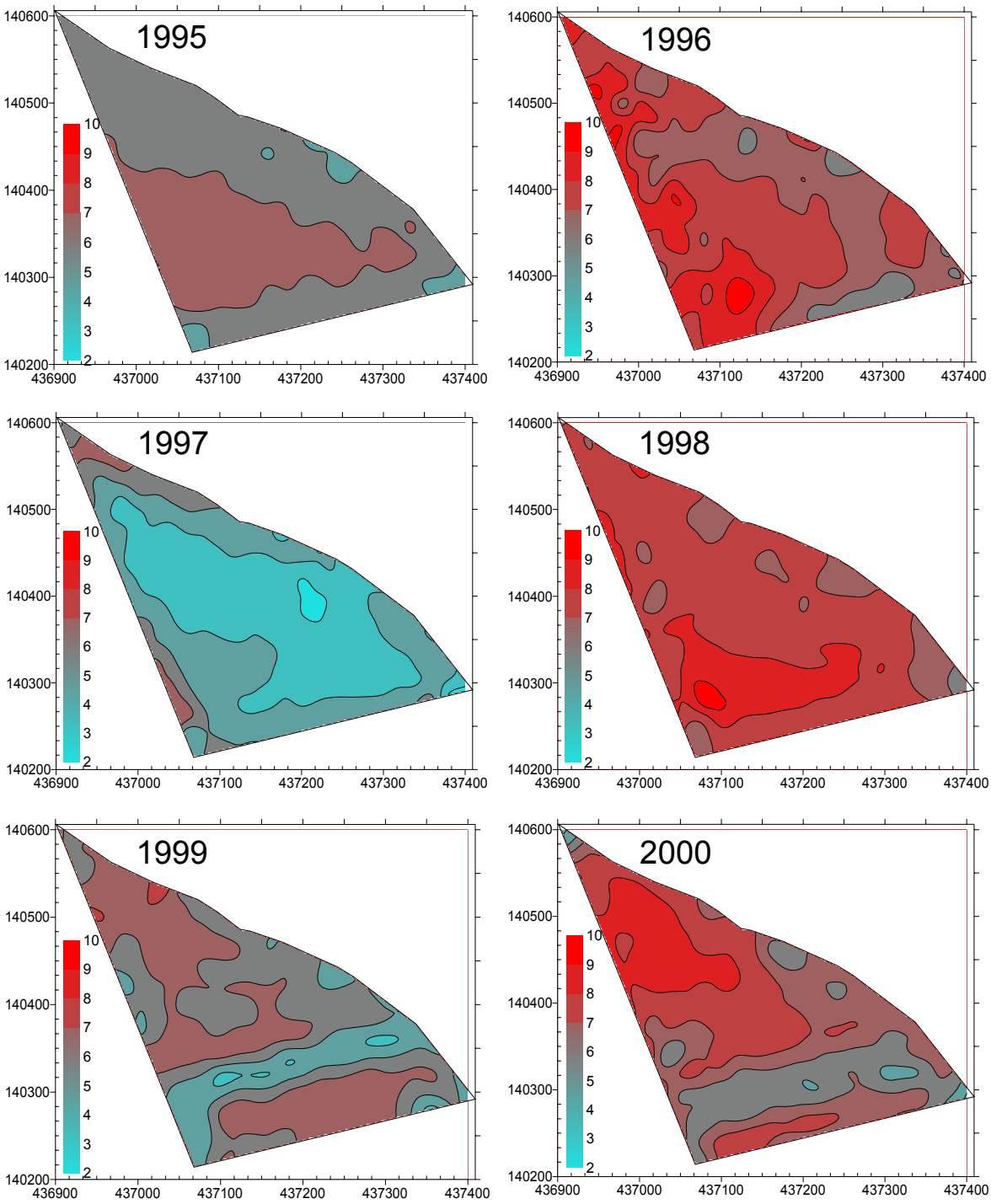
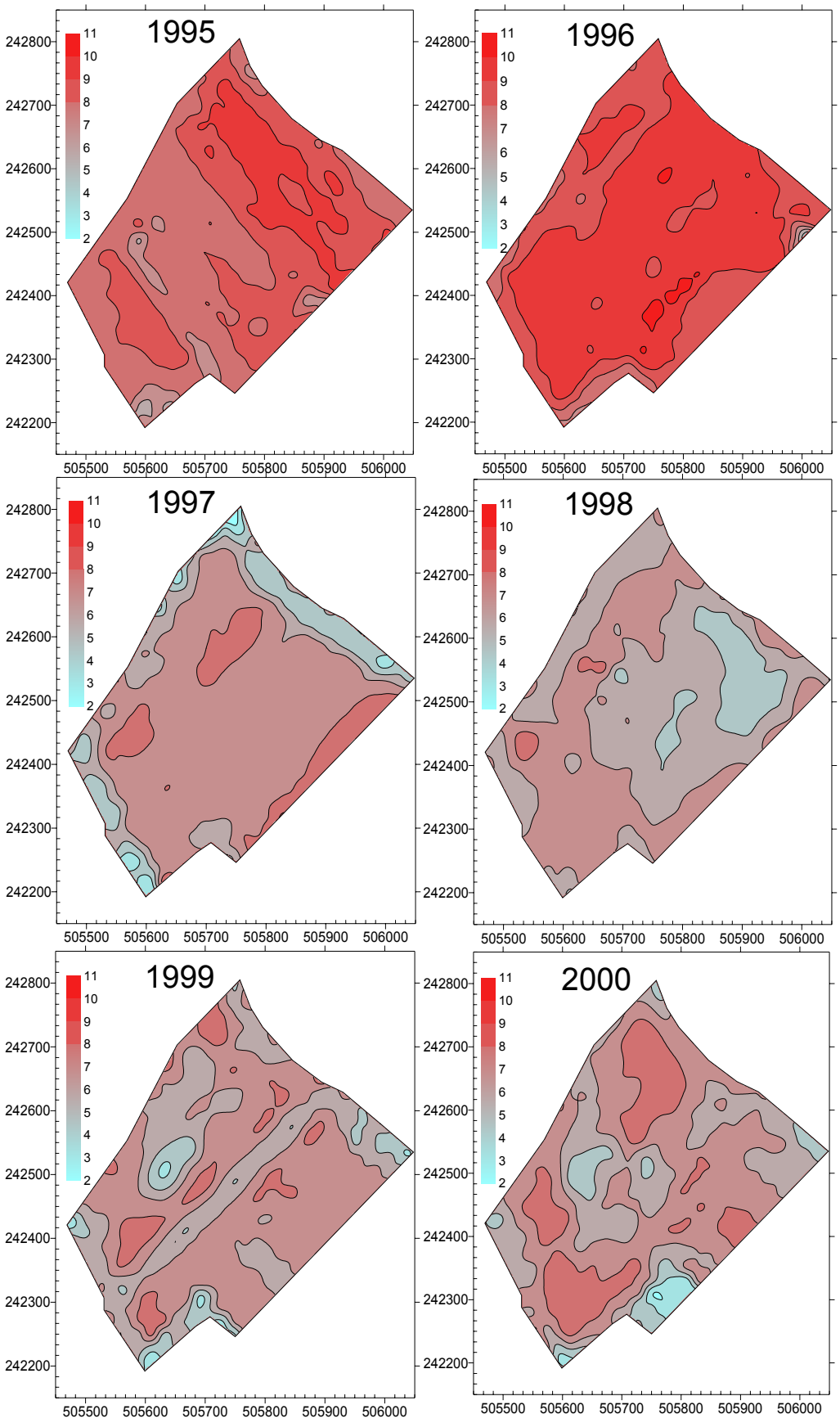


Fig 4. Six year yield histograms for the four fields



Trent Field yield maps



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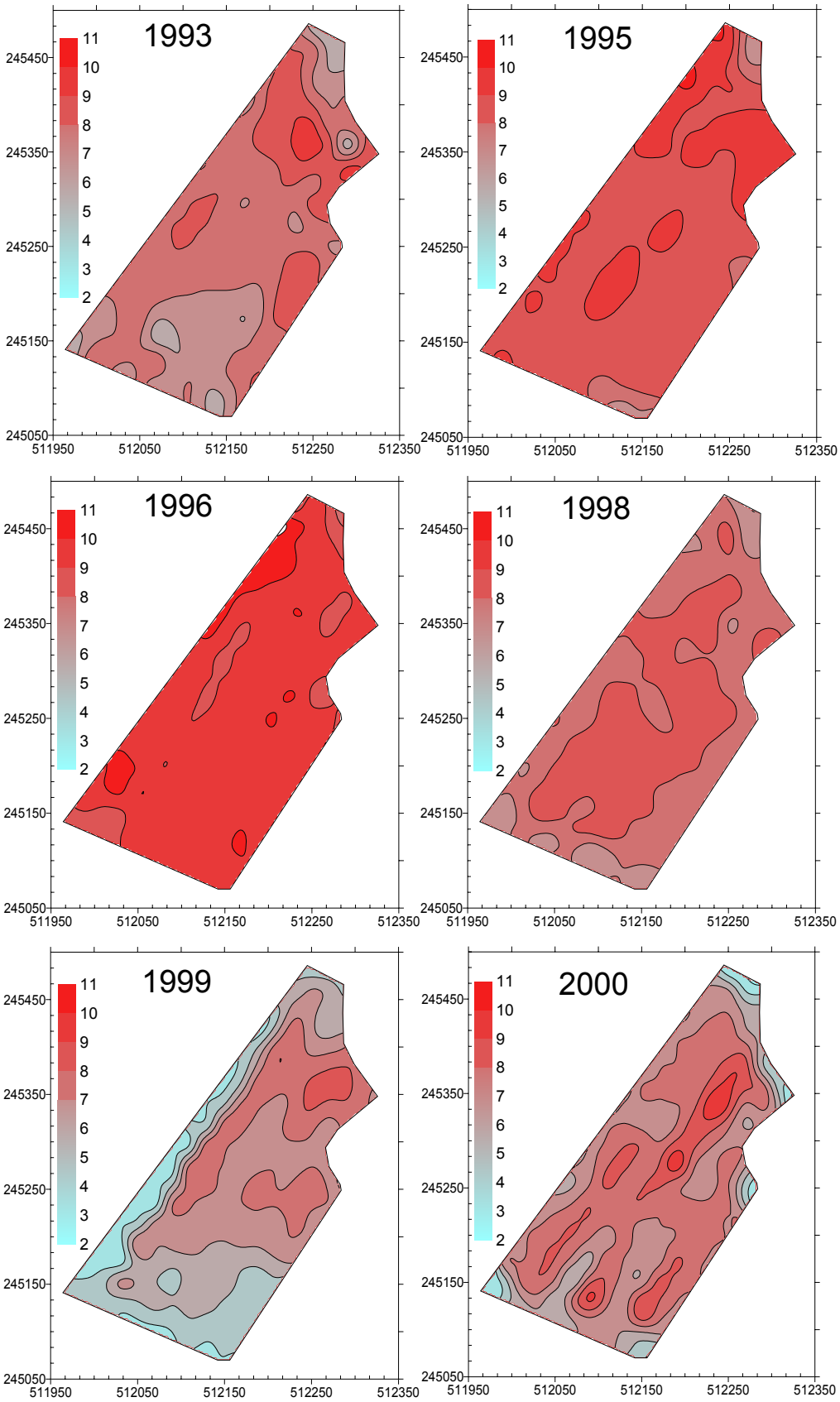
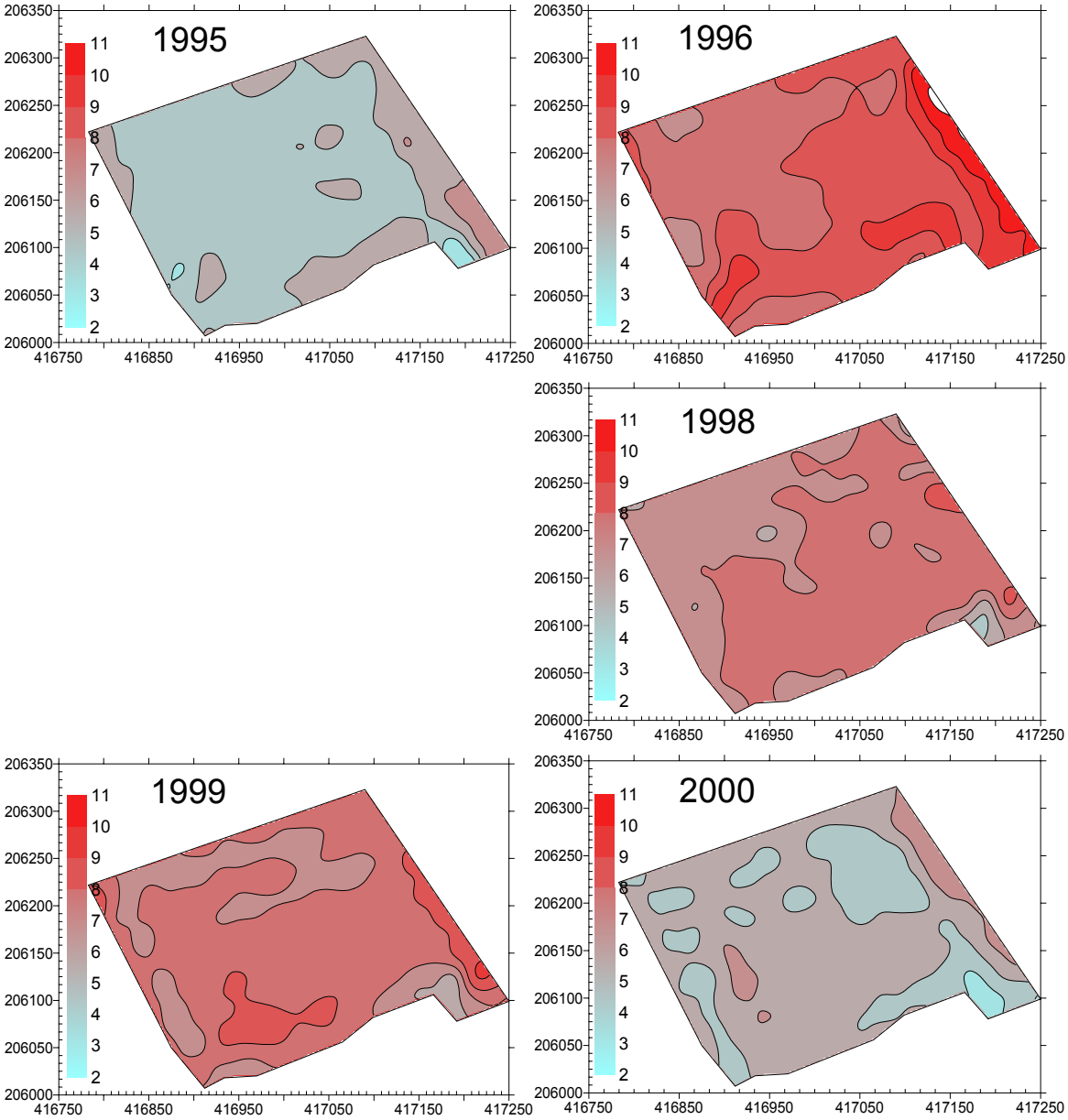


Far Sweetbrier yield maps



Twelve acres field yield maps

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