Australian National University

Spatial Design and Analysis of Tree Improvement Trials

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ANU

Early Days

- British cereal variety trials
  - Lattice designs (square and rectangular)
  - 1D blocking
- Alpha designs

Focus on Forestry

- Latinized row-column designs

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- ACIAR courses
  - Australia, China, Thailand Vietnam Kenya, Zimbabwe
    - mainly two-week duration

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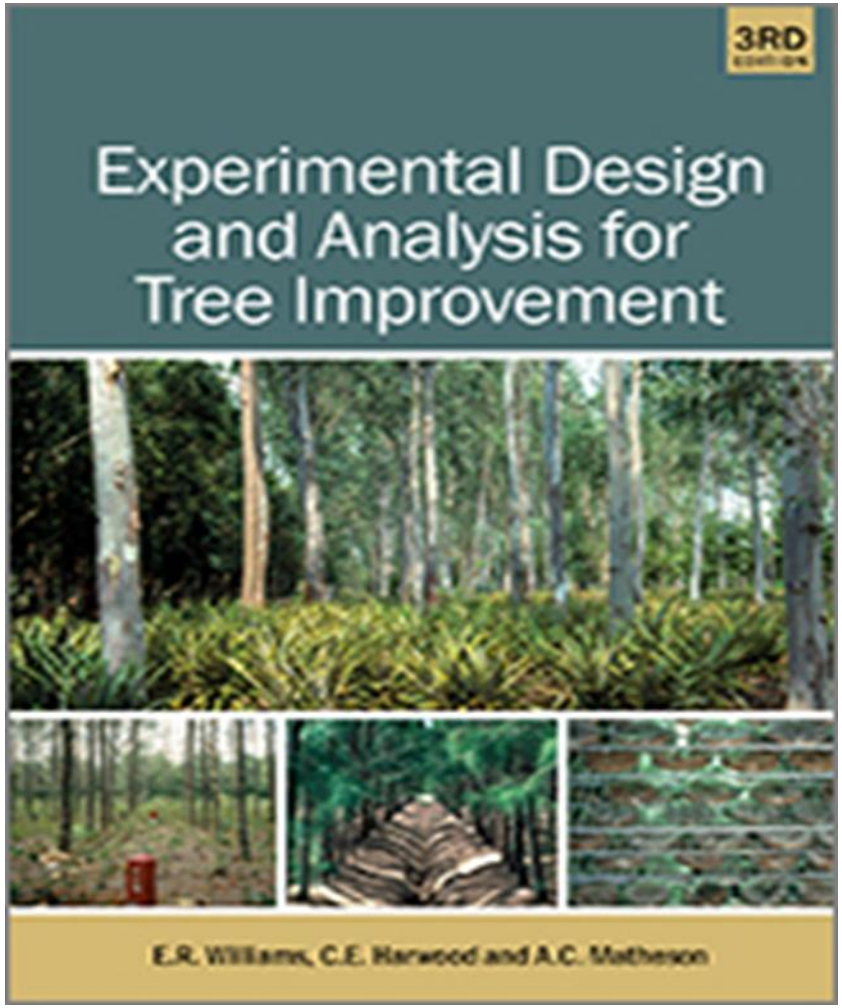
- Latinized row-column designs
- ACIAR courses
  - Australia, China, Thailand Vietnam Kenya, Zimbabwe
    - mainly two-week duration
- Tree Improvement book
  - 1st edition 1994
  - 2nd edition 2002

[Experimental Design and Analysis for Tree Improvement, E. Williams, C. Harwood, A. Matheson, January 2024, CSIRO Publishing]



Some differences between trees and annuals

- Measurements over time
- Plot structures
  - Single tree plots (STPs)
  - Line plots
  - 2D plots

Forest genetics and experimental design

- Single tree plots (White *et al.*, 2007)
  - Breeding values

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- Multiple tree plots
    - Plot summary file

Forest genetics and experimental design

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- Multiple tree plots
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- Compare analyses at *plots* and *trees* levels using some recent spatial methods

Some spatial models

- LV (1D Linear Variance)
  - Williams, 1986, Biometrika
- AR⊗AR (2D Autoregressive)
  - Cullis and Gleeson, J. Agricultural Science, 1989)
- LV⊗LV (2D Linear Variance)
  - Piepho and Williams, 2010, Plant Breeding
- LVIS (Linear Variance with Interaction Splines)
  - Piepho, Boer and Williams, 2022, Biometrical J.

Some analysis options

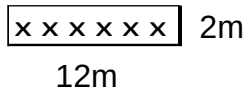
- Genstat
  - Vstructure (AR and LV)
  - V2DSPLINE (24th edition, Baird and Williams)
- SAS
  - Piepho *et al*. (2022, Biometrical J.)
- R
  - Boer (LMMsolver, 2023, Statistical Modelling)

Some (old) Forestry data sets

- Wagga (NSW) *Eucalyptus camaldulensis*, 5 tree line plots
- Kenya *Casuarina equisetifolia*, 25 tree plots (5 x 5)
- Codrington (NSW) *Melaleuca alternifolia,* 5 tree line plots

Wagga trial: 36 seedlots, latinized row-column design
6 replicates (4 x 9 plots); 6 tree line plots; 2m x 2m spacing

	Column	1	2	3	4	5	6	7	8	9
	Row									
	1	29	3	36	35	12	14	24	22	9
Rep 1	2	34	8	18	21	15	25	4	28	31
	3	13	33	5	6	20	30	23	7	26
	4	1	17	11	10	27	16	32	19	2
	1	32	23	16	9	31	35	19	20	1
Rep 2	2	15	22	33	5	7	18	2	34	24
	3	10	27	21	28	11	12	25	3	30
	4	26	6	13	17	29	4	36	14	8
	1	19	2	23	14	8	27	18	10	33
Rep 3	2	35	11	34	1	26	21	13	30	12
	3	24	20	15	31	36	7	28	4	6
	4	5	32	17	22	16	9	3	29	25
	1	12	5	27	34	30	2	20	8	22
Rep 4	2	7	25	26	16	3	29	1	18	35
	3	36	10	4	24	19	23	9	32	13
	4	17	31	14	11	21	28	33	6	15
	1	4	30	31	13	14	19	5	36	20
Rep 5	2	22	15	12	32	2	6	29	21	16
	3	11	9	3	25	35	26	8	23	28
	4	33	18	24	7	17	34	27	1	10
	1	16	26	7	33	4	22	30	2	21
Rep 6	2	18	28	20	29	9	10	6	24	14
	3	23	1	35	15	25	36	11	27	5
	4	31	12	8	19	34	3	17	13	32

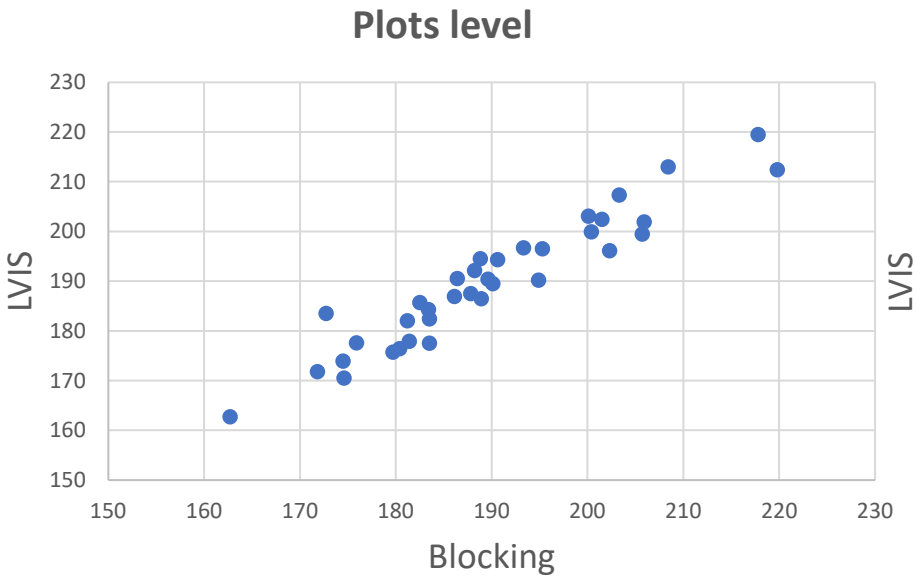


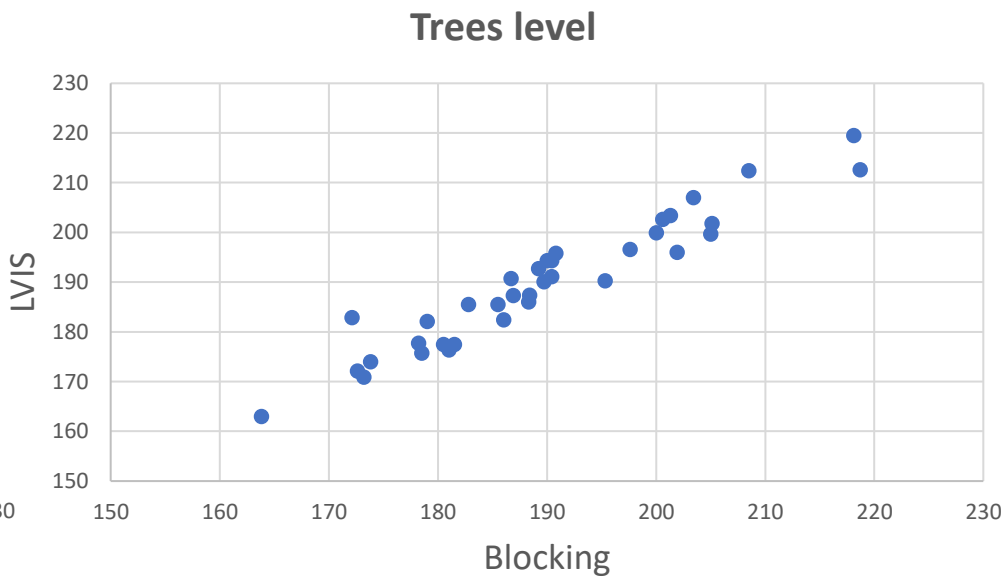
Wagga trial: 36 seedlots, latinized row-column design
6 replicates (4 x 9 plots); 6 tree line plots; 2m x 2m spacing

AIC values

	Plots level	*Trees* level
Replicate+family (fixed)	1739.80	12680.51
+repl.column	1713.86	12579.94
+repl.row.column		12562.93
+AR⊗AR	1691.80 (0.91, 0.71)	12543.45 (0.87, 0.96)
+LV⊗LV	1690.27	12541.33
+LVIS	1680.37	12529.51

Wagga estimated family means





Family SEDs

	Plots	Trees
Blocking	13.73	13.67
+LVIS	12.23	12.23

Kenya trial: 25 provenances, latinized row-column design
4 replicates (5 x 5 plots); 25 tree square plots; 2m x 2m spacing

AIC values

	Plots level	*Trees* level
Replicate+family (fixed)	48.19	4449.37
+repl.column	37.36	4338.24
+repl.row.column		4285.91
+AR⊗AR	fail	4211.49 (0.96, 0.94)
+LV⊗LV	fail	4215.30
+LVIS	43.01	4216.08

Codrington trial: 60 seedlots, latinized row-column design
2 x 2 replicates (6 x 10 plots); 5 tree line plots; 1m x 0.3m spacing

AIC values

	Plots level	*Trees* level
Replicate+family (fixed)	1396.04	9783.14
+repl.column+repl.row	1379.28	9744.99
+repl.row.column		9741.88
+AR⊗AR	fail	fail
+LV⊗LV	fail	fail
+LVIS	1376.72	9738.94

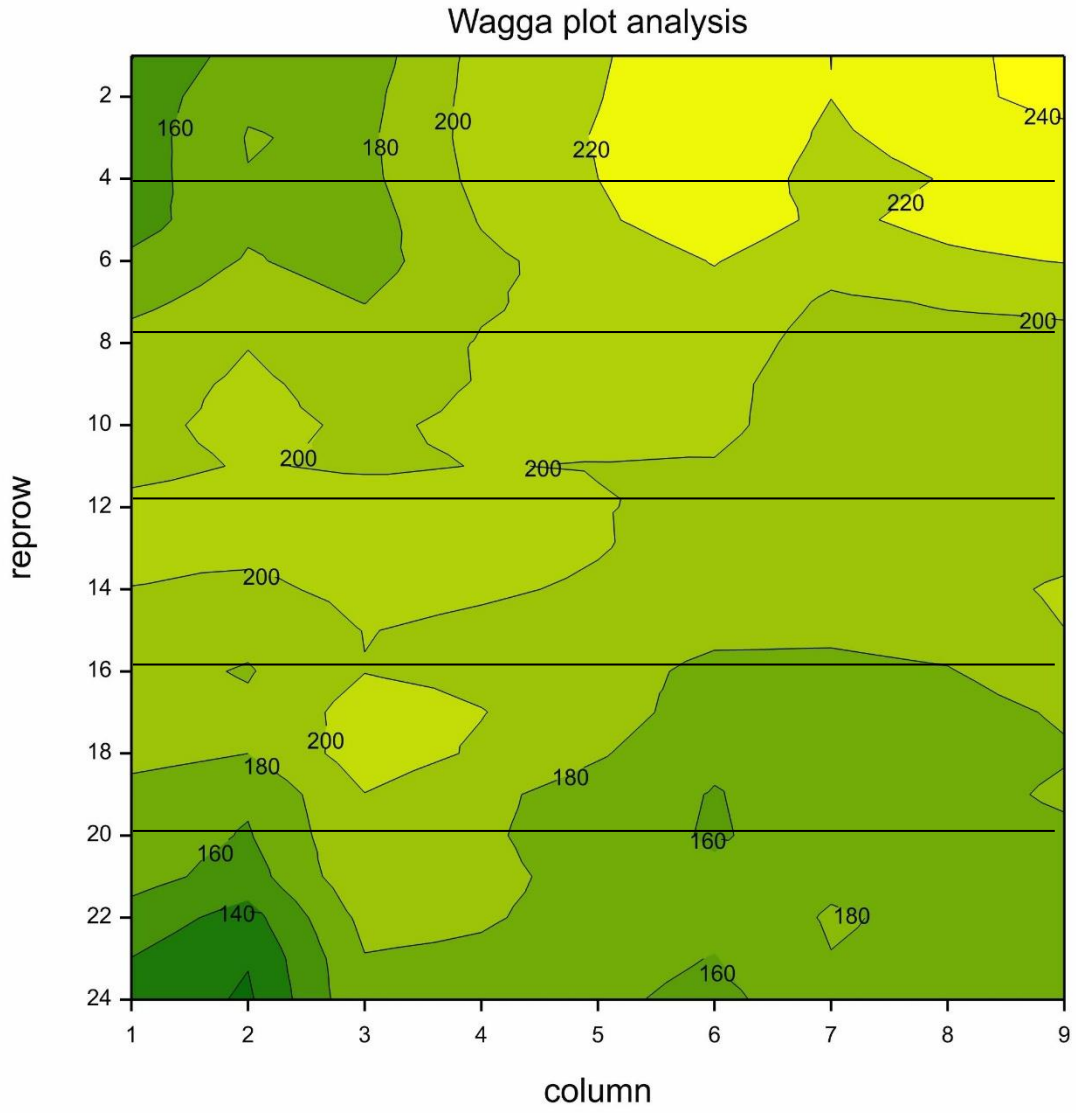
Summary

- Spatial may not provide a value-add to (adequate) conventional blocking
- More likely to need to include spatial when analyses are at the *trees* level
- Spatial method may be related to the size of autocorrelations (usually unknown at the design stage)

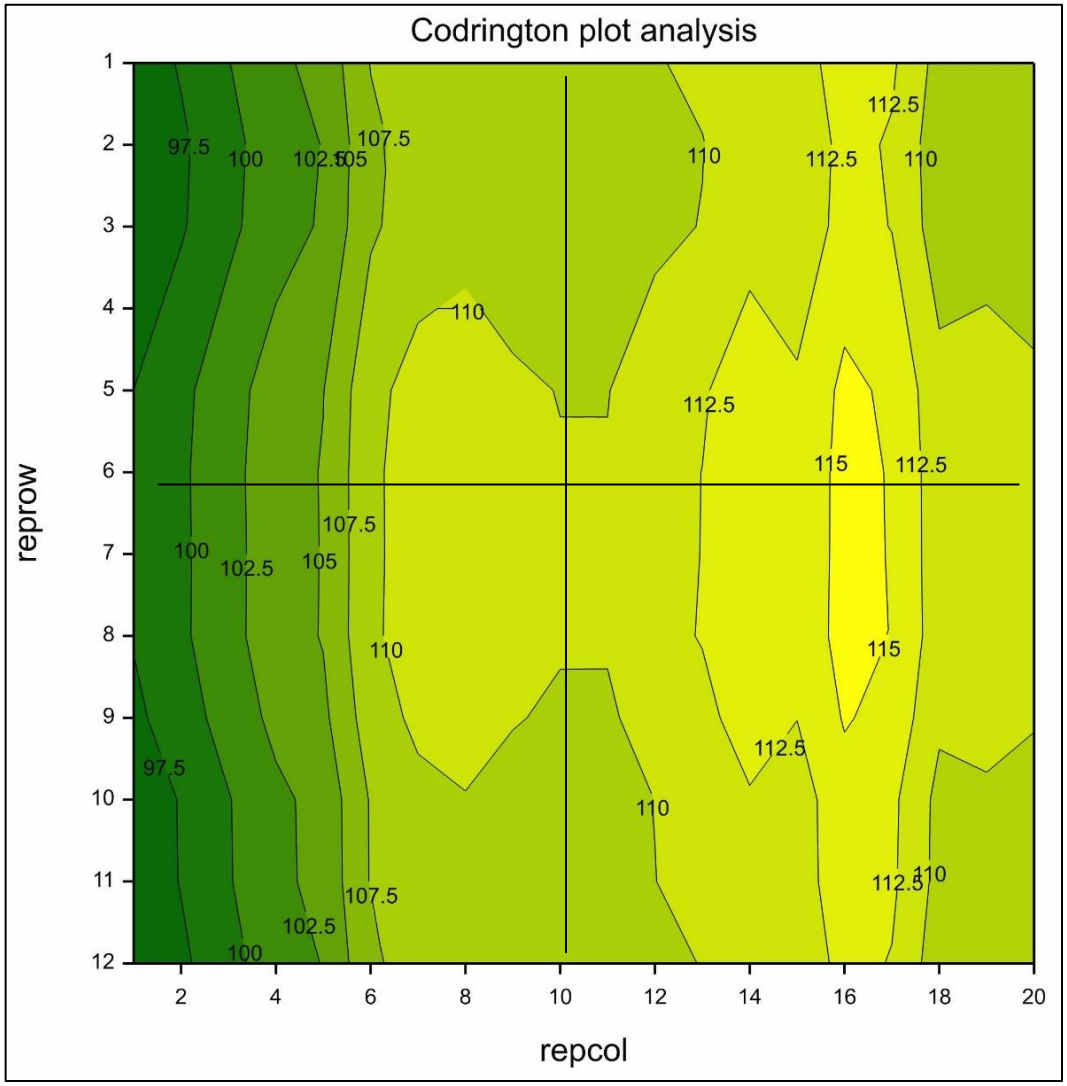
Spatial design
Model based vs model free

- Model based and random treatments
  - Input values for spatial parameters
- Model free
  - NB&ED designs
    - (Piepho, Williams and Michel, 2021, J. Agronomy and Crop Science)
  - Implemented in CycDesigN version 8

Wagga contour plot



Codrington contour plot



Kenya contour plot