Using Multivariate Control Charts to Communicate Long-Term Changes in Community Composition

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Joint Fire Science Program

- Disturbances and interventions affect communities (multiple species) simultaneously
- How can we visualize / communicate these changes?

Sagebrush-Steppe Habitats

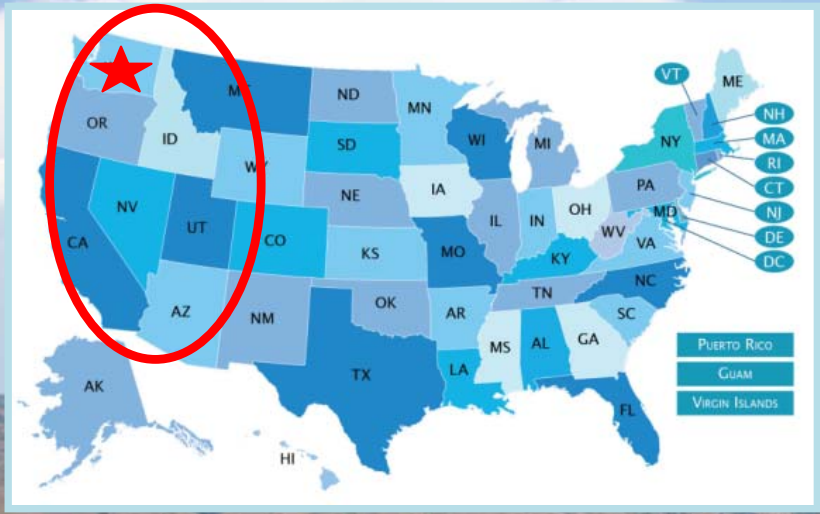


Photo by GM Davies

24 Command Fire (2000)
~65,000 ha
(160,000 acres)

Photos:
H Newsome, USFWS (right)
R Bose, Tri-City Herald (above)

Photos by GM Davies

How to visualize community change?

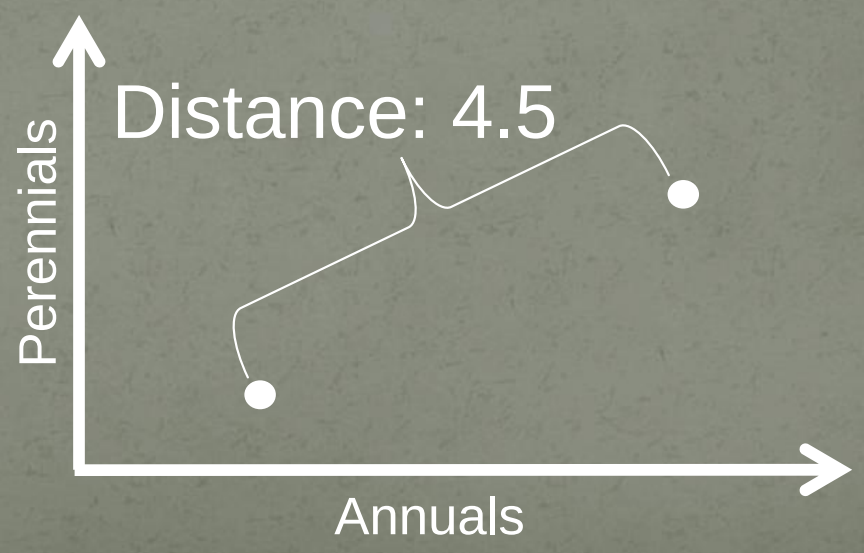
- One species at a time is inefficient and overwhelming
- Multivariate Control Charts (MCCs) are
  - Flexible
  - Visual
  - Statistically rigorous
- Based on the ecological distance among observations

Univariate Distance

	Total Cover
Plot 1	4
Plot 2	10

Bivariate Distance

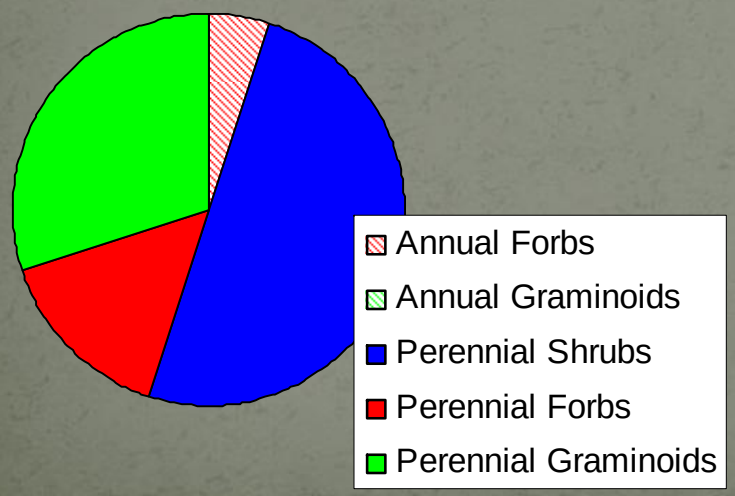
	Annuals	Perennials
Plot 1	3	1
Plot 2	7	3



Multivariate Distances

By Species:

	SppA	SppB	…	Spp *p*
Plot 1				
Plot 2				



By Life Form:

	AF	AG	PF	PG	PS
Plot 1					
Plot 2					

One Common Summary

	Total Cover
Plot 1	4
Plot 2	10
…	
Plot *n*	

	Annuals	Perennials
Plot 1	3	1
Plot 2	7	3
…		
Plot *n*		

	AF	AG	PF	PG	PS
Plot 1					
Plot 2					
…					
Plot *n*					

n x *n* distance matrix

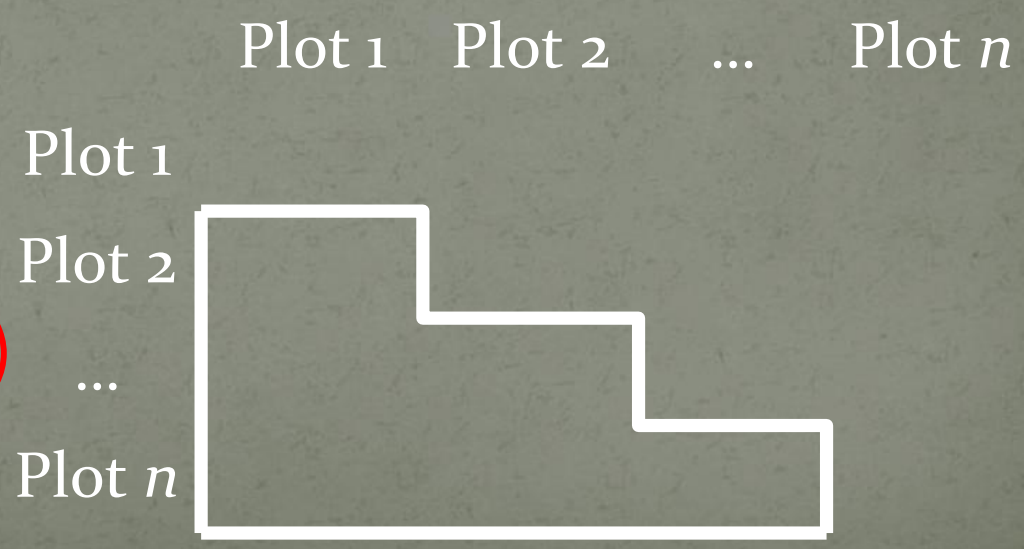
	Plot 1	Plot 2	…	Plot *n*
Plot 1				
Plot 2				
…				
Plot *n*				

Features of the Distance Matrix

	Plot 1	Plot 2	…	Plot *n*
Plot 1	0			
Plot 2		0		
…			0	
Plot *n*				0

n x *n* distance matrix

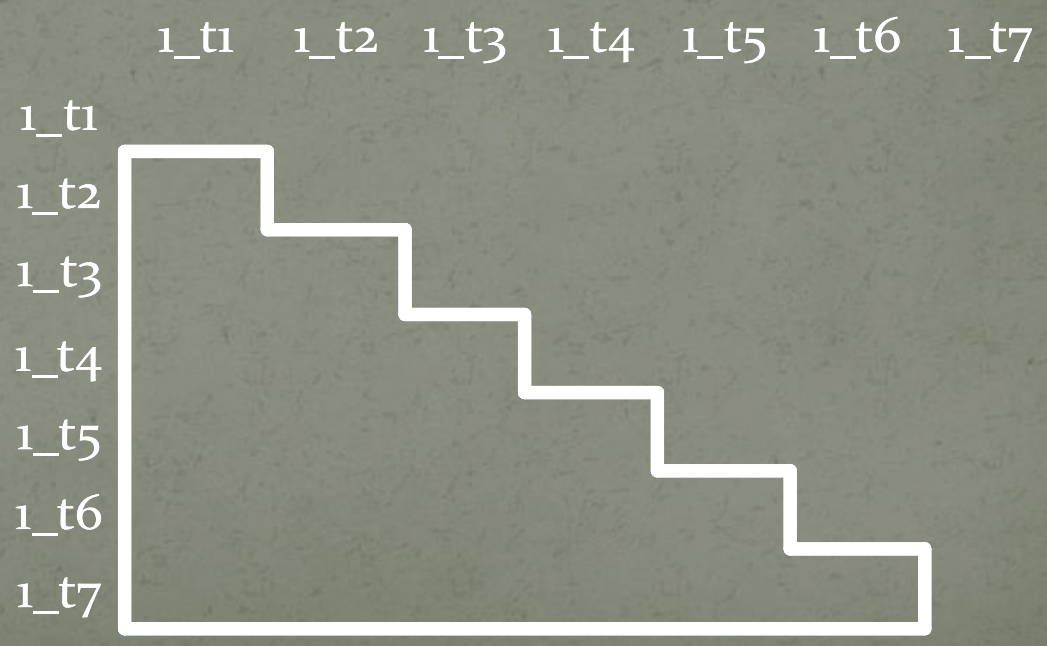
Also a *n* x *n* distance matrix



Permanent Plots

- Remeasurements permit analyses of compositional change over time

7 x 7 distance matrix of one plot over time



Multivariate Control Charts (MCCs)

- Focus on desired elements from distance matrix (unlike ordination, which uses entire matrix)
  - Static: Fixed points in time
  - Dynamic: Mean prior composition
- Analyze multiple plots to examine overall trends

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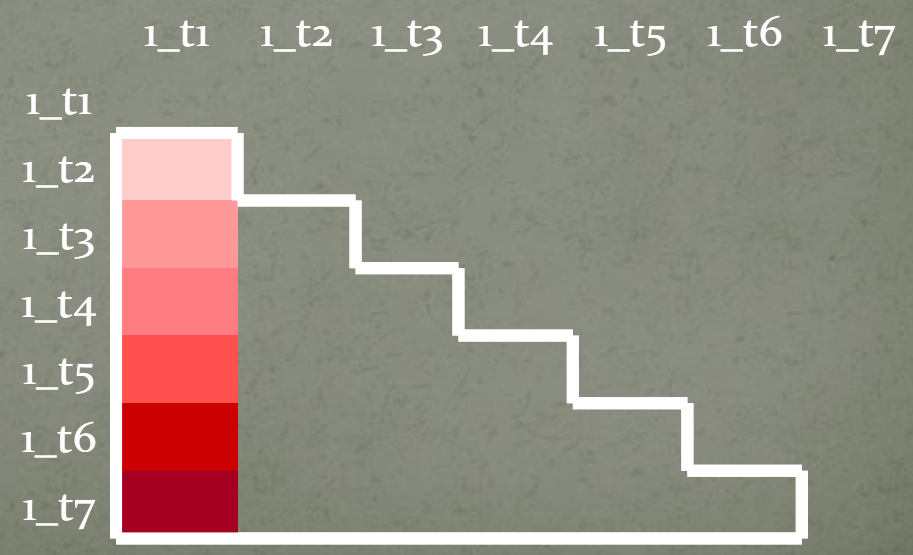
MULTIVARIATE CONTROL CHARTS FOR ECOLOGICAL AND ENVIRONMENTAL MONITORING

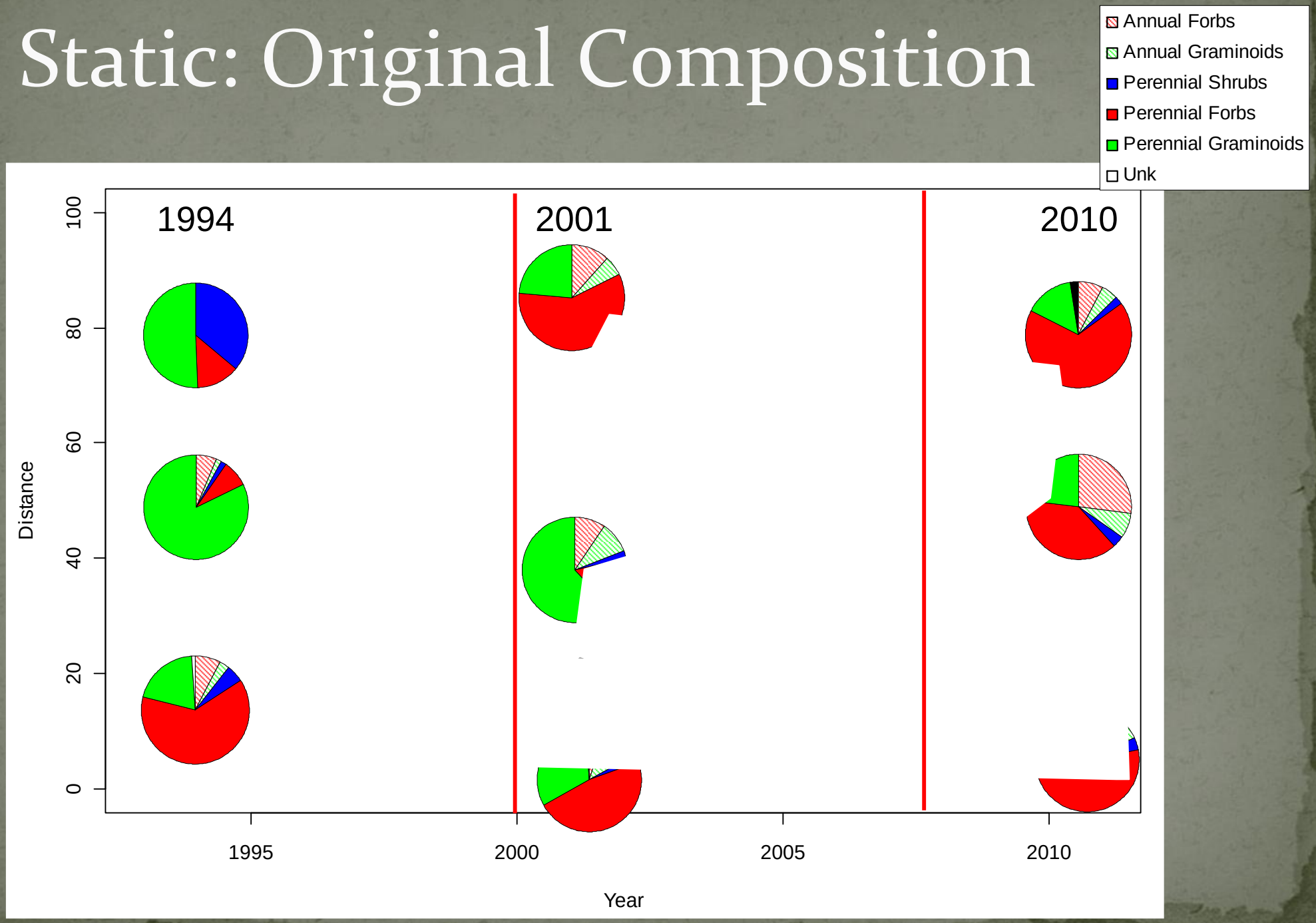
MARTI J. ANDERSON[1,3] AND ANGUS A. THOMPSON[2]

Static Comparisons

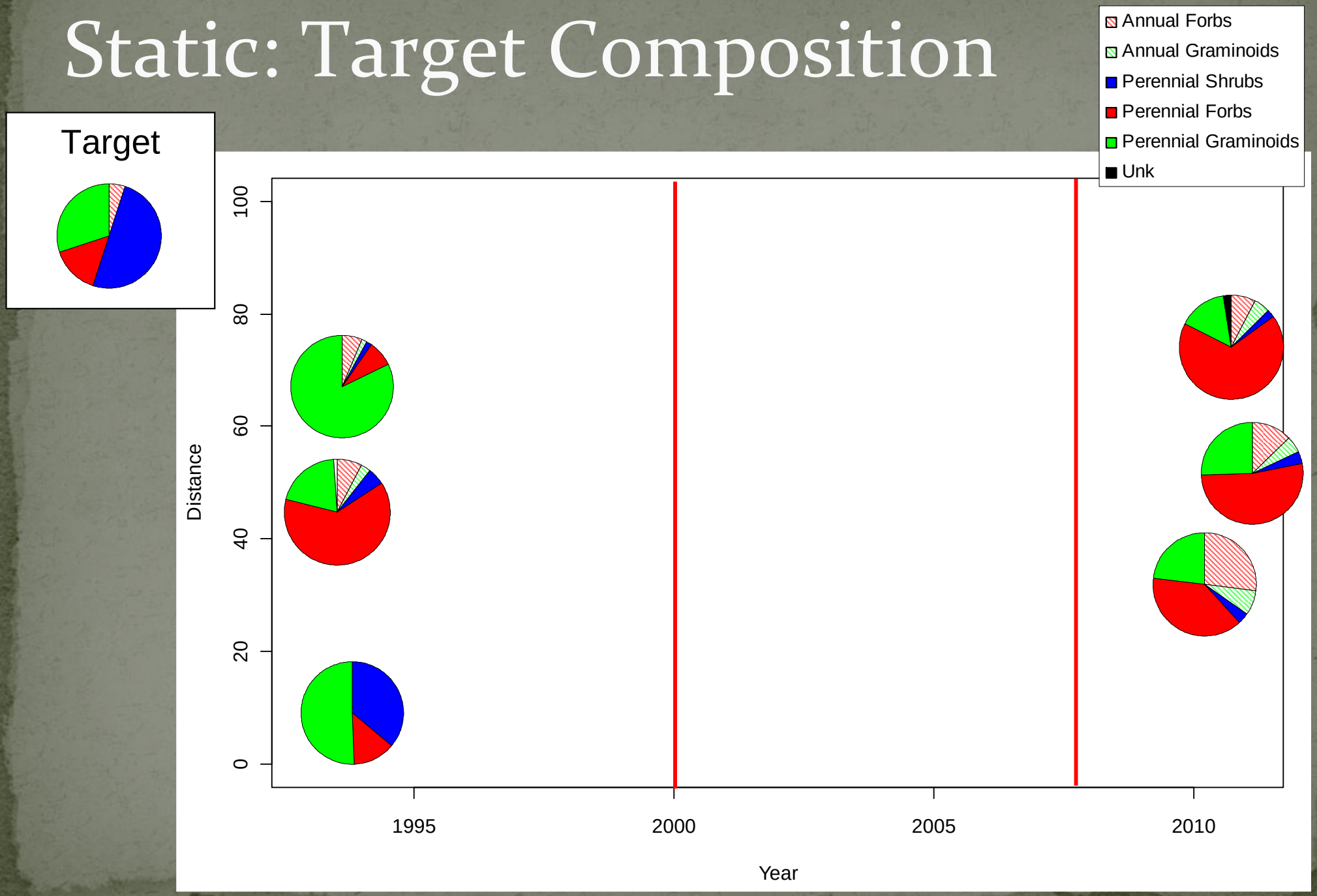
- Compare each time with one or more specified times
- Appropriate for:
  - Response to an episodic disturbance
  - Deviation to/from a desired state



Static: Original Composition

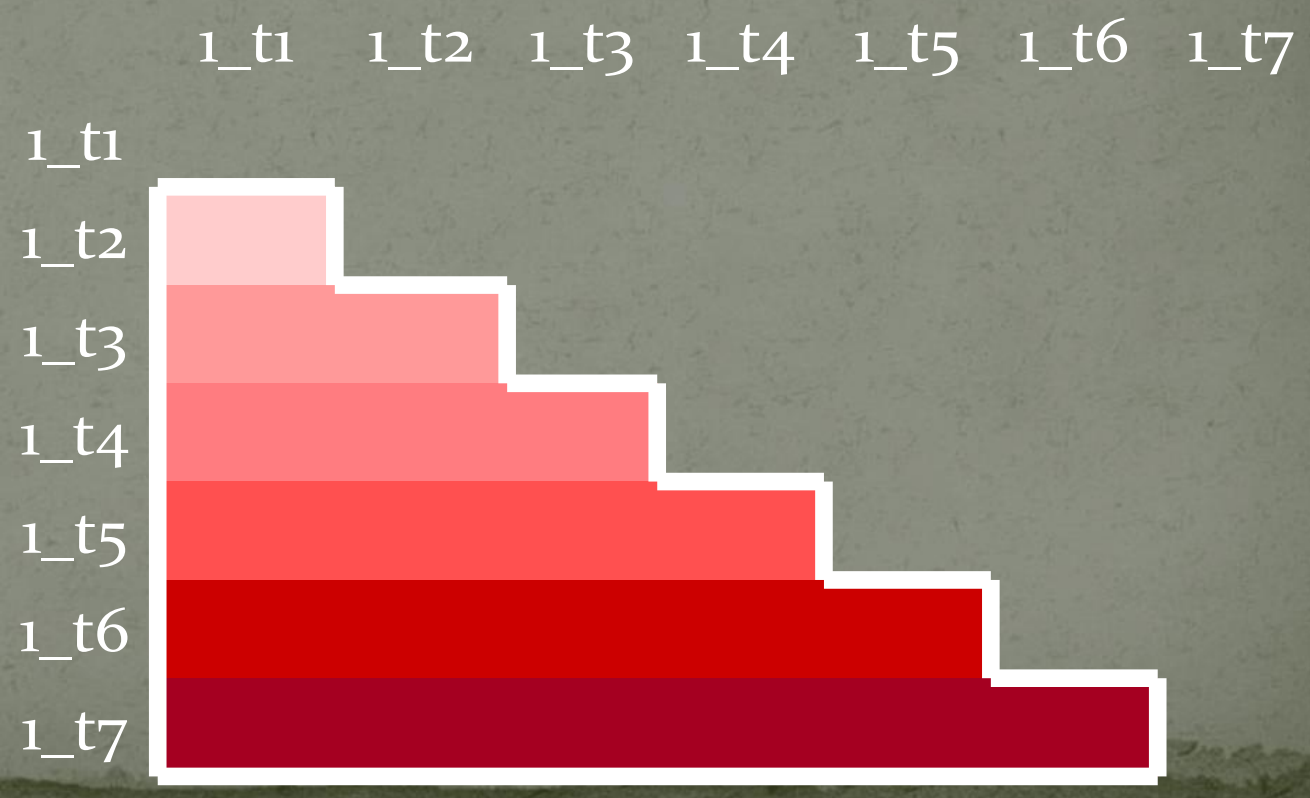


Static: Target Composition

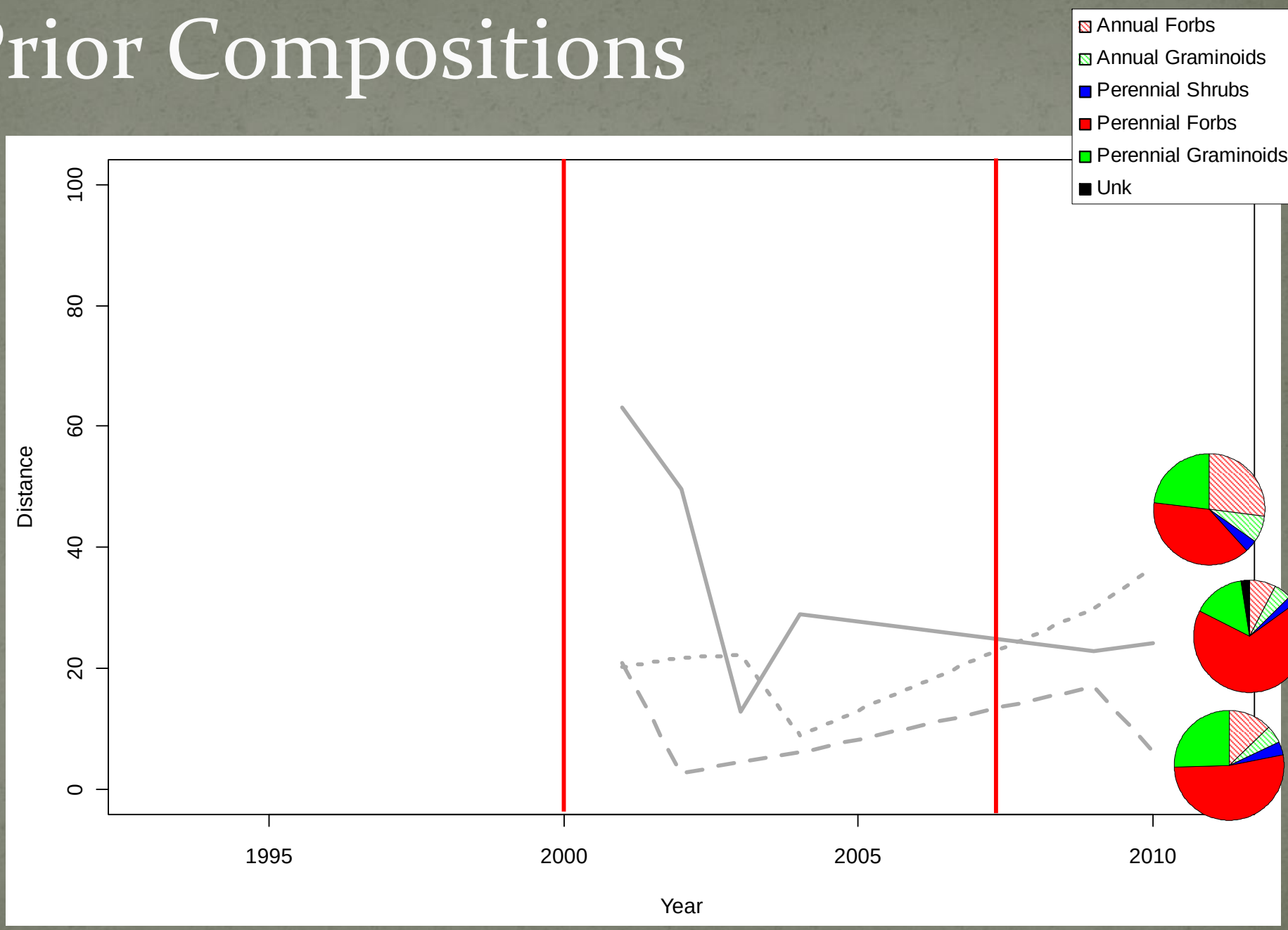


Prior Compositions

- Appropriate for:
  - Response to chronic disturbances
  - Temporal dynamics



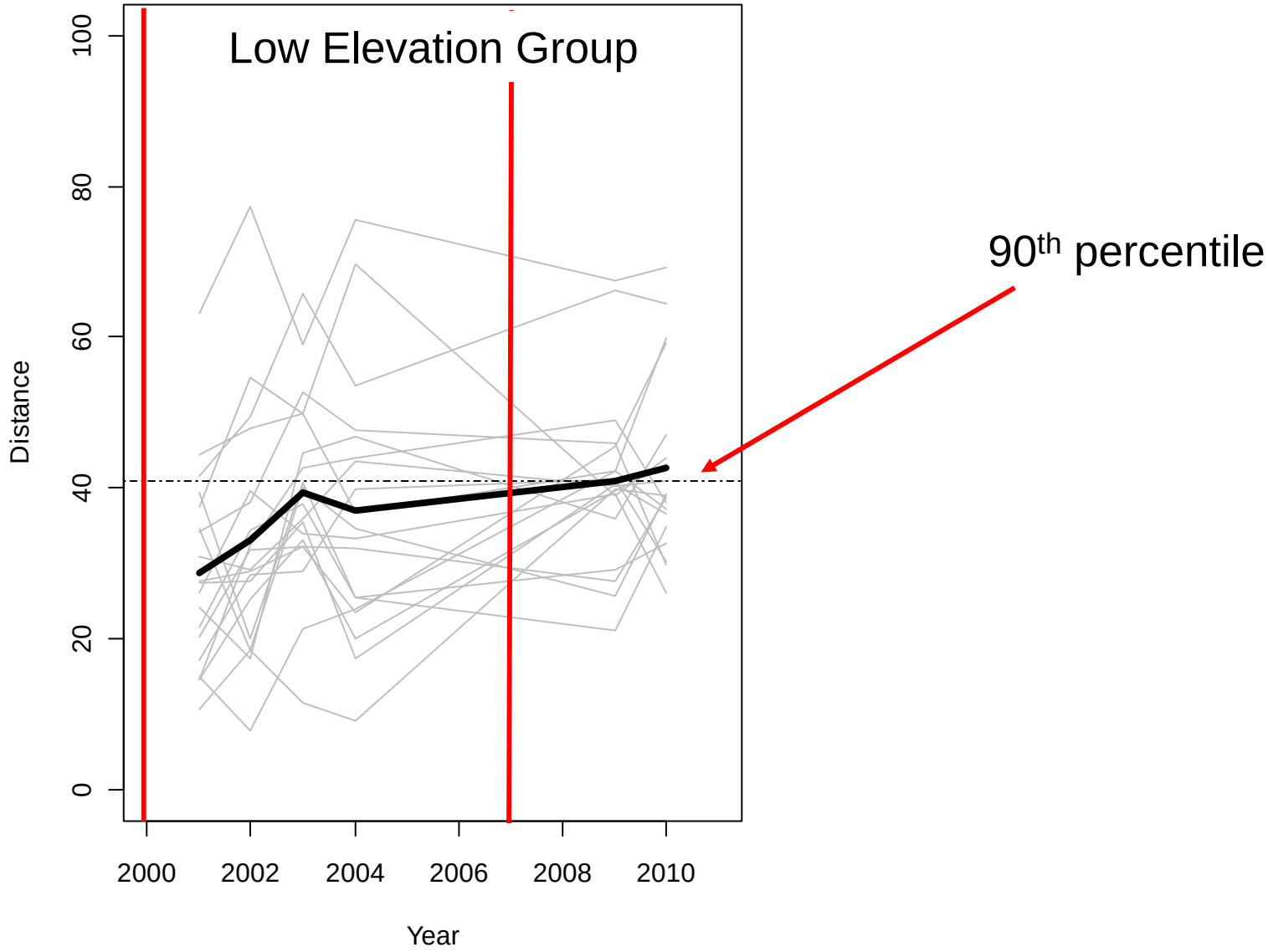
Prior Compositions



Combining Multiple Plots

- Mean trajectories over time
- Assess statistical significance via bootstrapping

Change from Original Composition



Conclusions

- MCCs are a powerful means of visually understanding compositional change:
  - Detecting community-level response to disturbance or interventions
  - Quantifying recovery
- Deserve additional application in restoration monitoring
- Can be accompanied by other analyses to examine:
  - Type of change
  - Directionality of change
  - Causality

Acknowledgements

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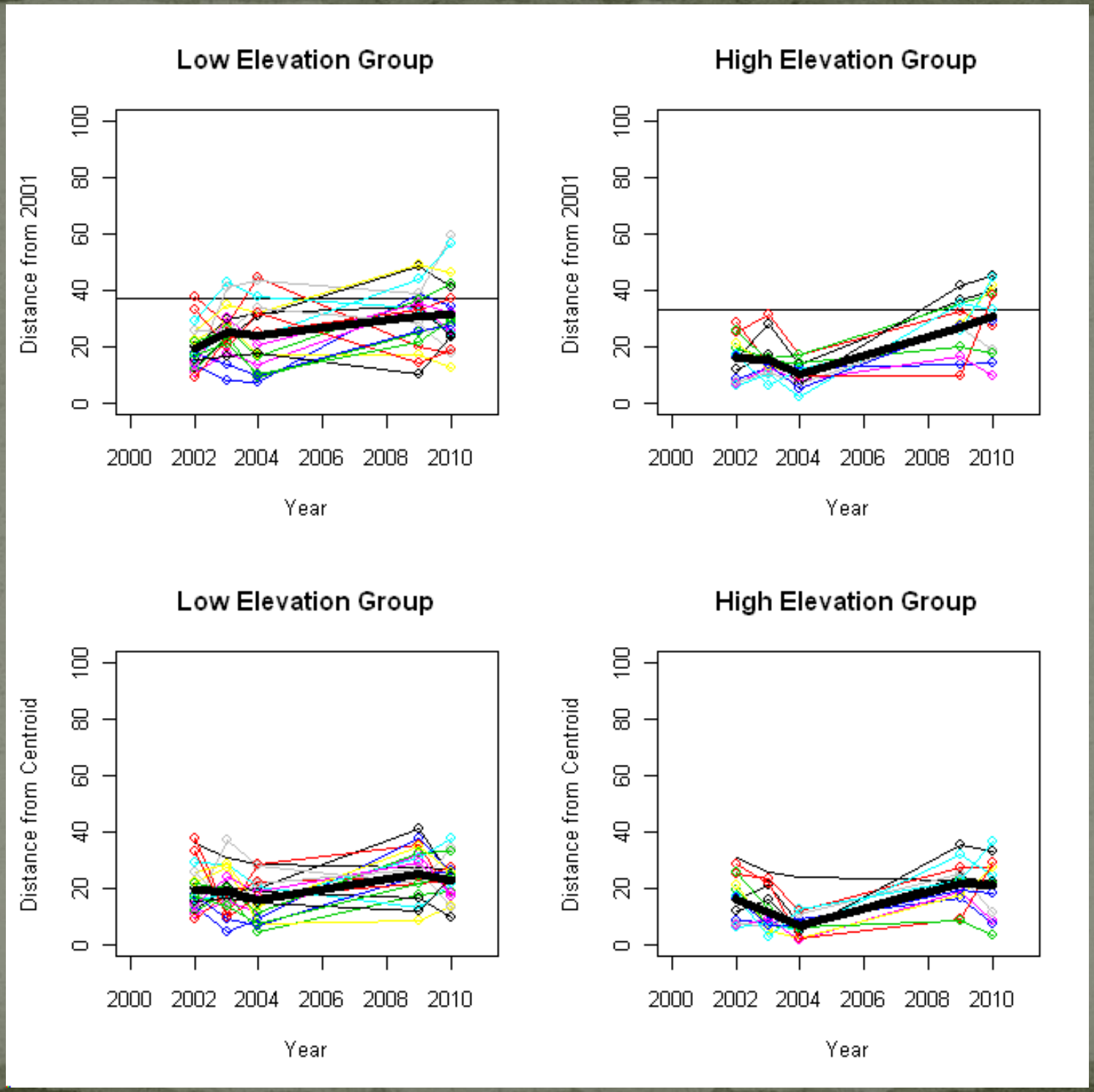
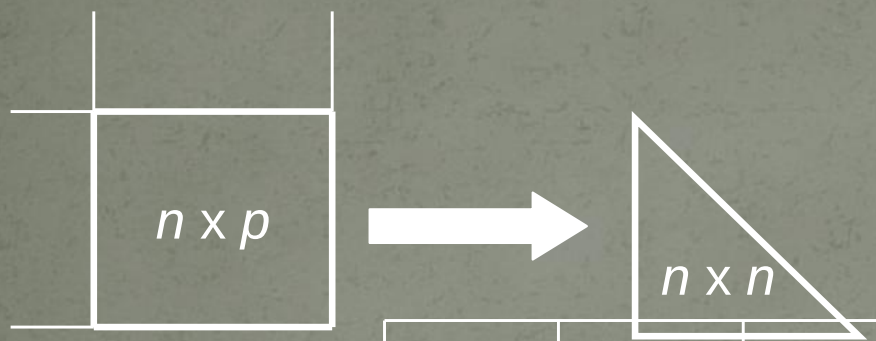
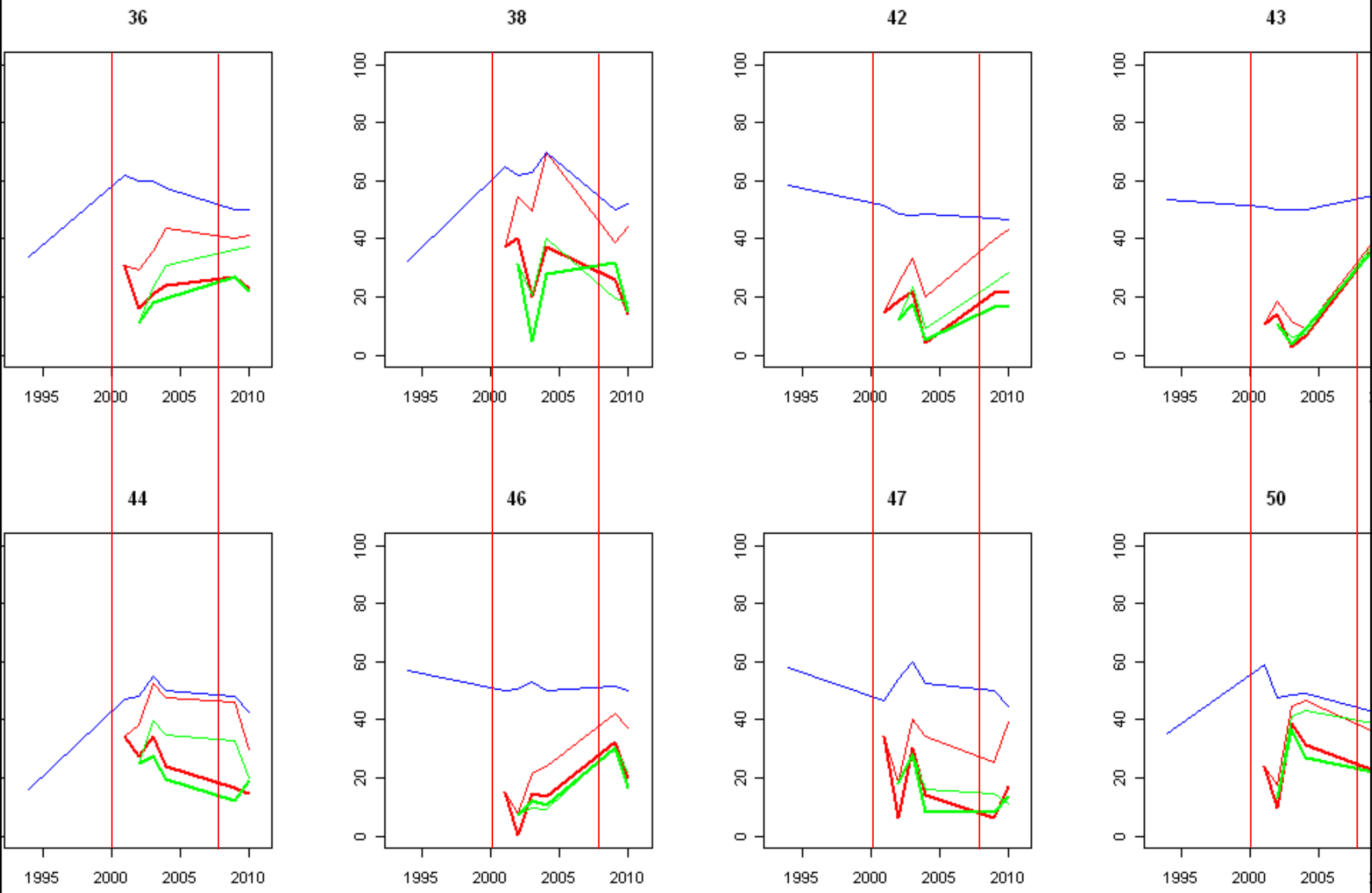
- Establishment of permanent plots:
  - Janelle Downs, Mike Marsh, Dave Wilderman


Low Elevation Group
High Elevation Group
Low Elevation Group
High Elevation Group
Distance from 2001
Distance from Centroid
Year
0
20
40
60
80
100
2000
2002
2004
2006
2008
2010



	1_t1	1_t2	1_t3	1_t4	1_t5	1_t6	1_t7
1_t1							
1_t2							
1_t3							
1_t4							
1_t5							
1_t6							
1_t7							

- Remeasurements of permanent plots permit consideration of compositional distance over time
- Focus on desired elements from distance matrix (whereas compositional analysis uses entire matrix)


36
38
42
43
44
46
47
50
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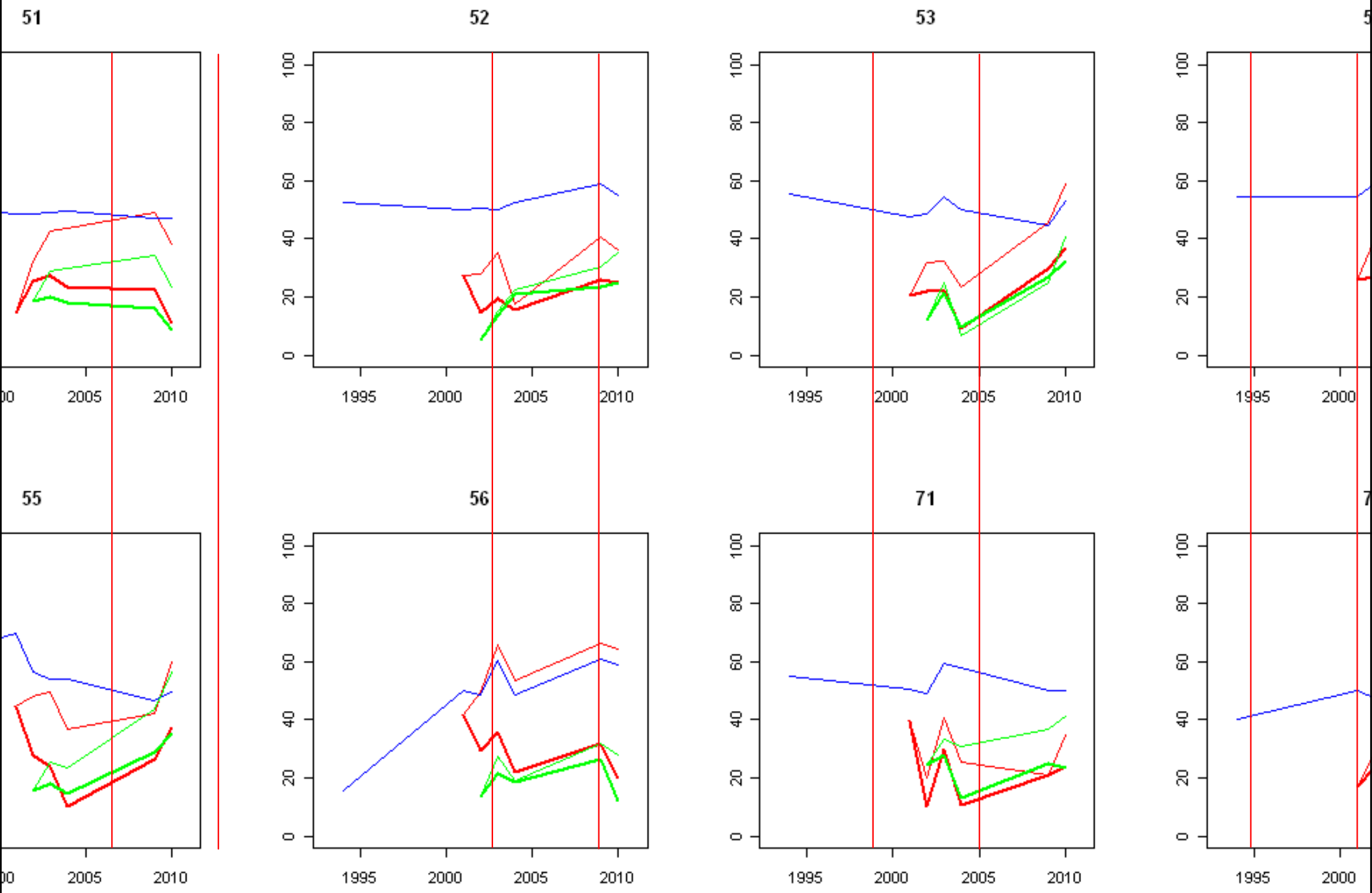
40
60
80
100
1995
2000
2005
2010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56
71
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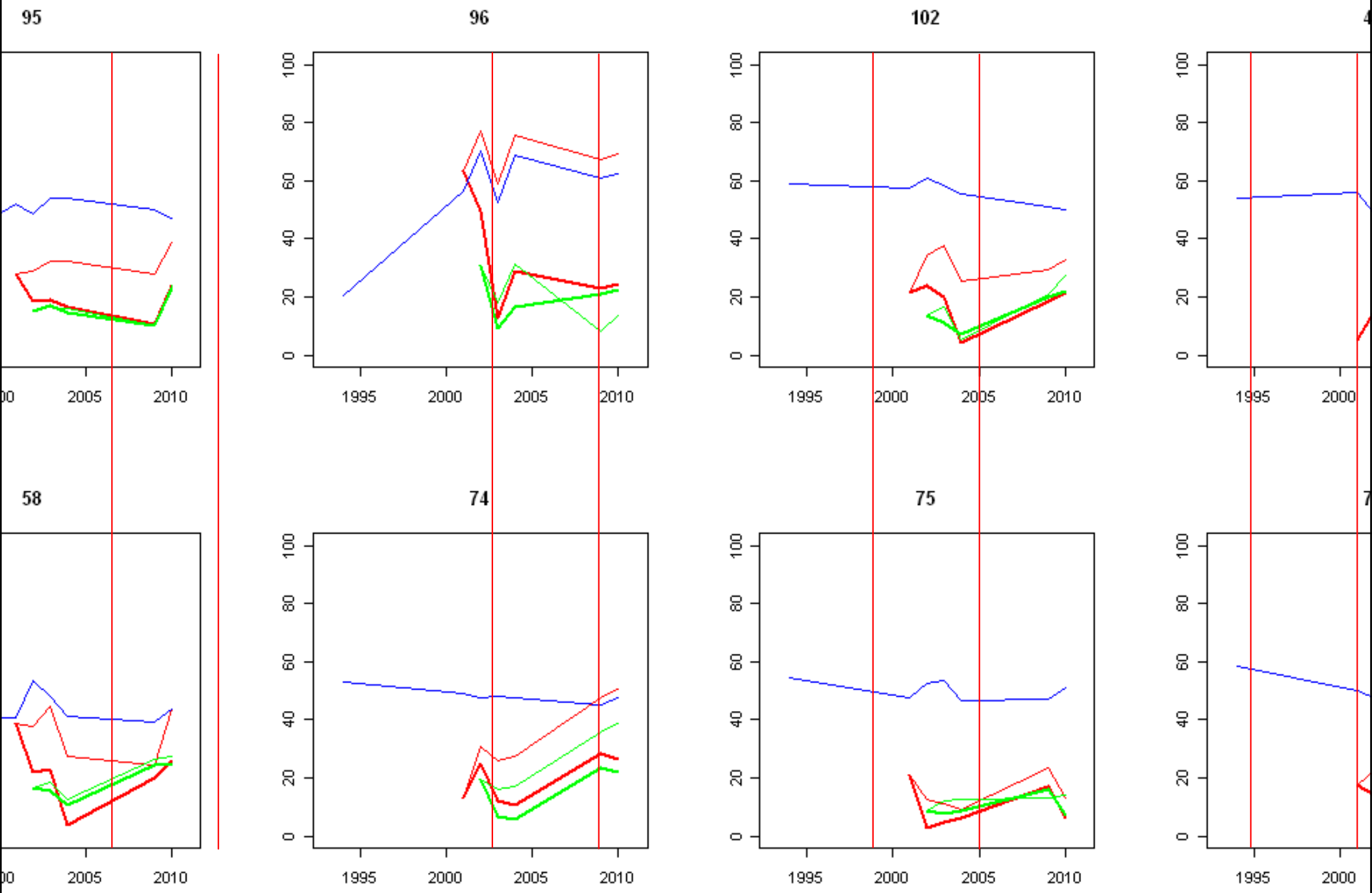
1995
2000
2005
2010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1995
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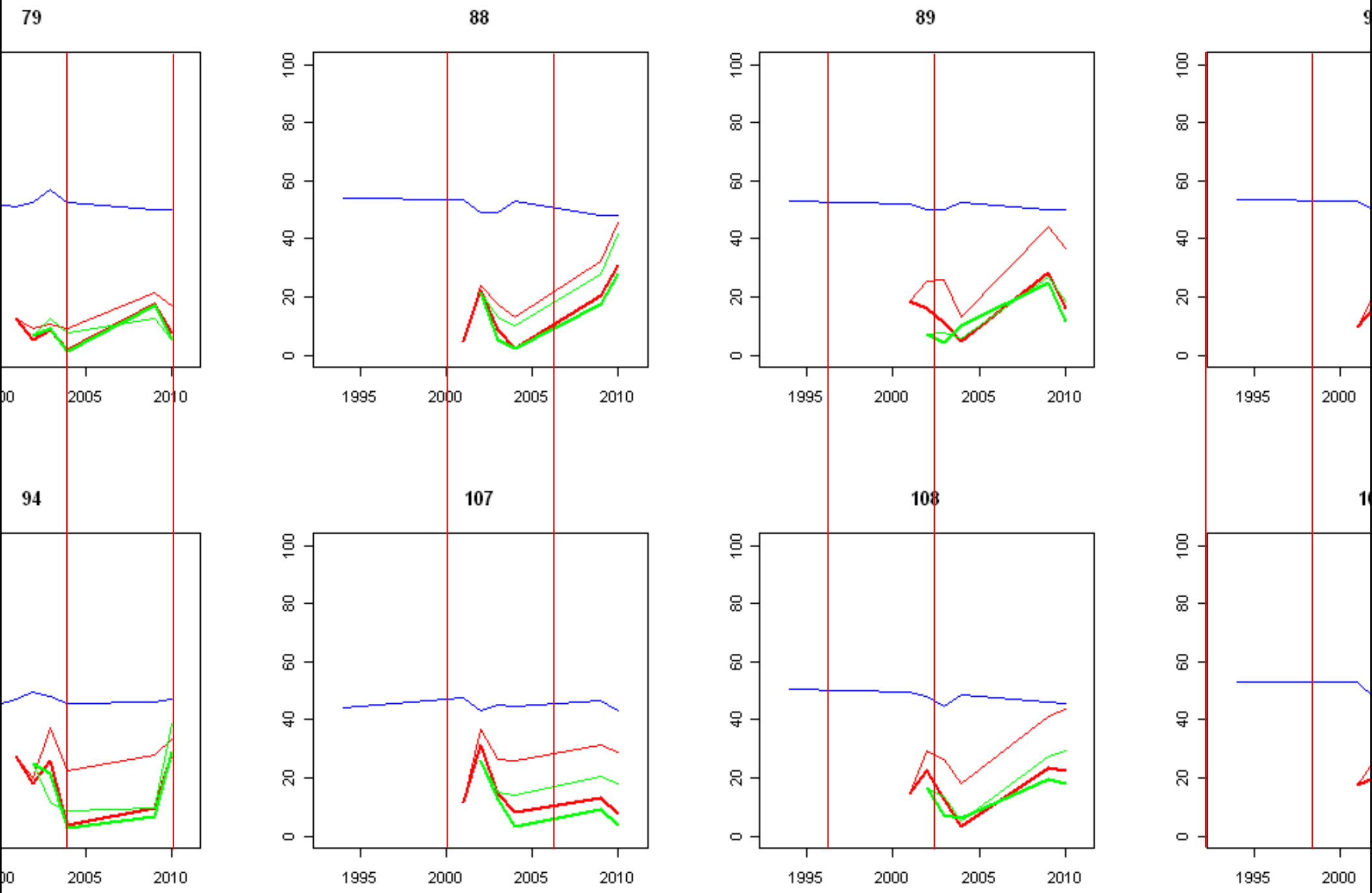
2010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0
20
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1995
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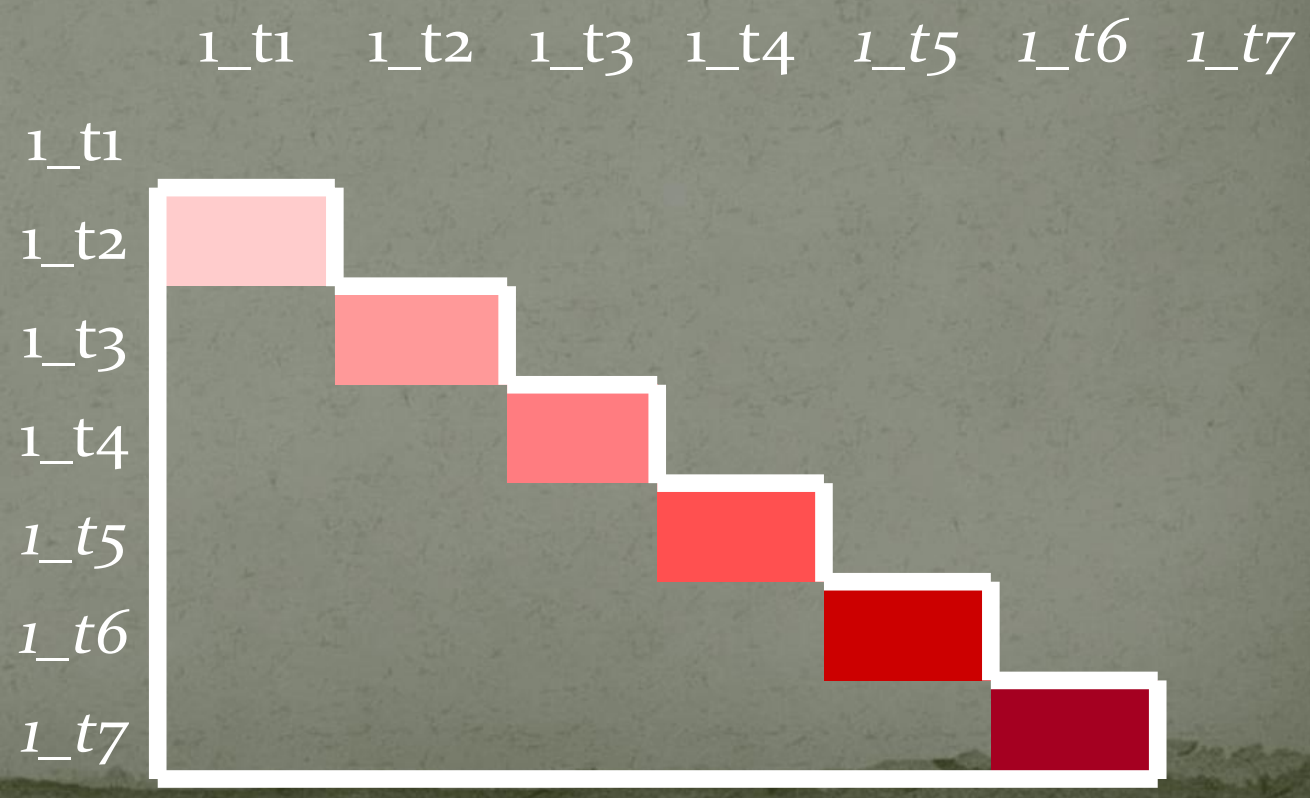
Previous Composition