Nutrient Dynamics of Planted Forests
Vancouver, Wa
Nov, 2012

INTER-ROTATIONAL PRODUCTIVITY AND NUTRITION IN *Pinus radiata* PLANTATIONS

JOHN TURNER and MARCIA LAMBERT
FORSCI PTY LTD
AUSTRALIA

RADIATA PINE PLANTATIONS

- Species native to California (~10,000ha)
- About 3.7 million ha in the southern hemisphere mainly in Chile, New Zealand and Australia
- Commercial scale planting commenced in early 20^{th} century
- Usually grown on 25-35 year rotations
- In Australia initially planted on sites considered not suitable for other purposes, often nutritionally poor
- Significant areas now converting to second and third rotations

BROAD MANAGEMENT PRINCIPLES DEVELOPED:

- Site specific management
  - site classification system
  - Site specific information
- Plantations to be sustainable
  - can productivity be maintained across rotations?
  - range of other values
- Changes in management over time

Eucalyptus forest converted to plantation

First rotation plantation. Original timber removed by hand and pit planted

Windrowing and burning of native vegetation for first rotation pine

Radiata growing in windrow

Site preparation of pasture site for first rotation

Early deformity of radiata on site with high mineral nitrogen

Weed management critical

Sandy site, residue burnt and replanted

Maintenance of harvesting slash in establishment of second rotation

STUDY BACKGROUND

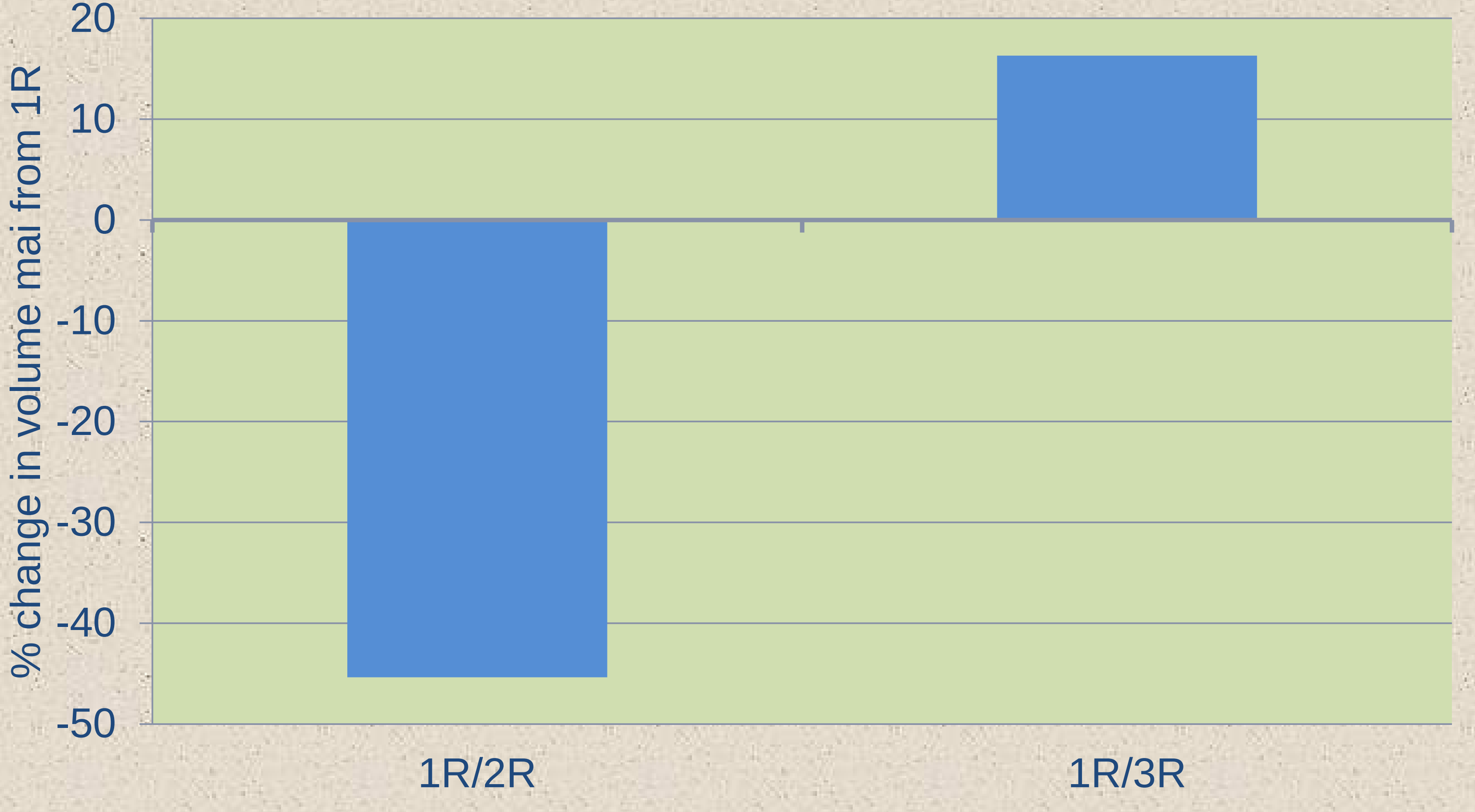
Radiata plantations are being converted to 2nd, 3rd or 4th rotations and the issues are:

- Does the productive capacity (fertility) of a pine plantation site change over rotations?
- Are there changes in plantation productivity?
- Are the changes in soil related to productivity (directly or through nutritional status)?
- Can sites be categorised on the basis of risk of productive capacity change and plan management intervention?

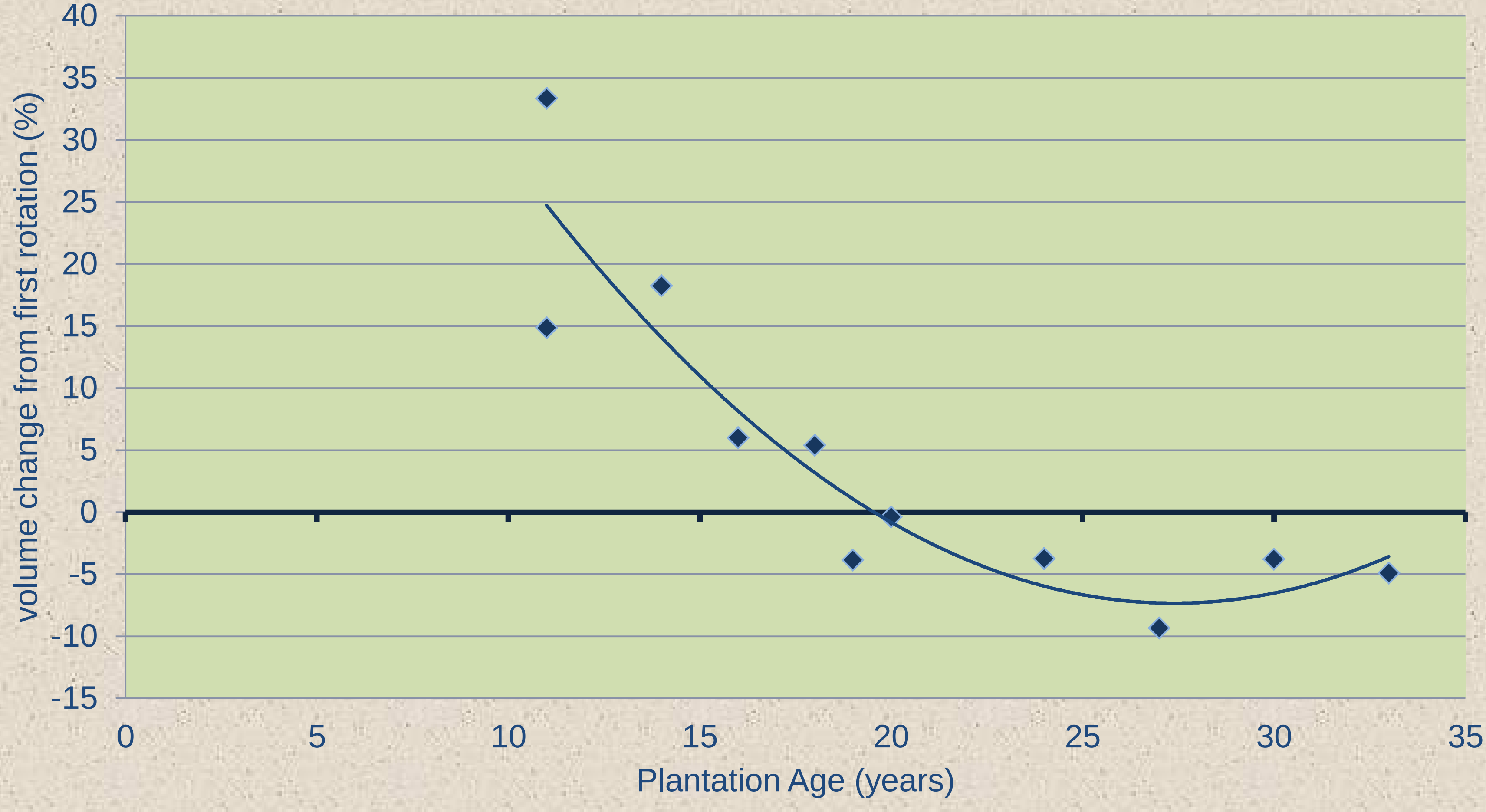
Project Issues

- Compare soil properties between rotations
- Measure productivity between rotations
- Assess management over rotations
- Need to relate changes in productivity to changes in soil properties and/or plantation management [finding a change in soil properties and in productivity does not mean they are related]
- Issue of short term and long term change?
- Should we be concerned?

(Keeves 1966) productivity decline of radiata on fine sands.
(O'Herir and Nambiar 2010) extended to 3R and showed improvement.



Second rotation productivity related to first rotation and age



Radiata Pine plantation site variation

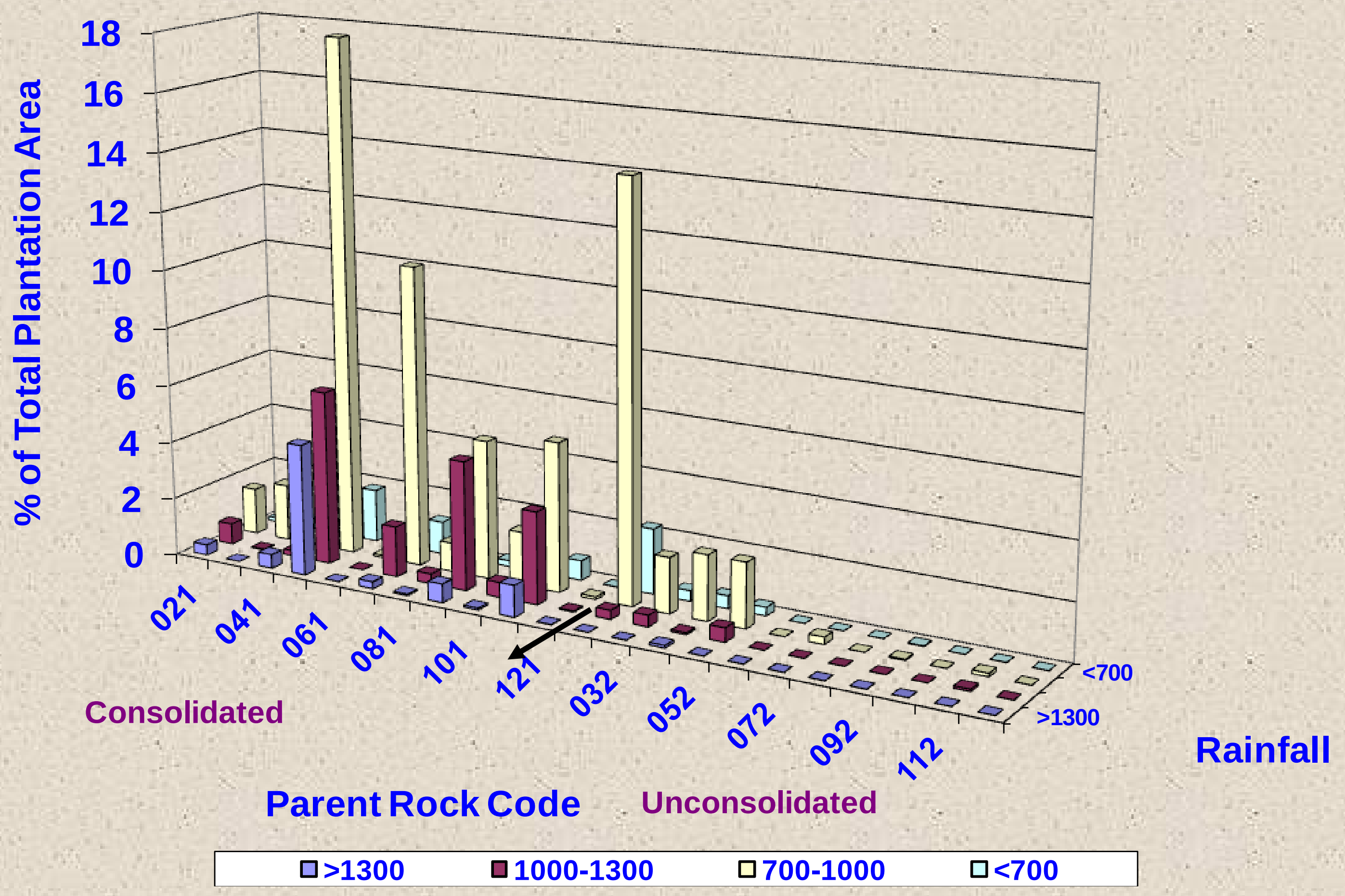
- Categorised on basis rainfall x

  Soil Technical Classification

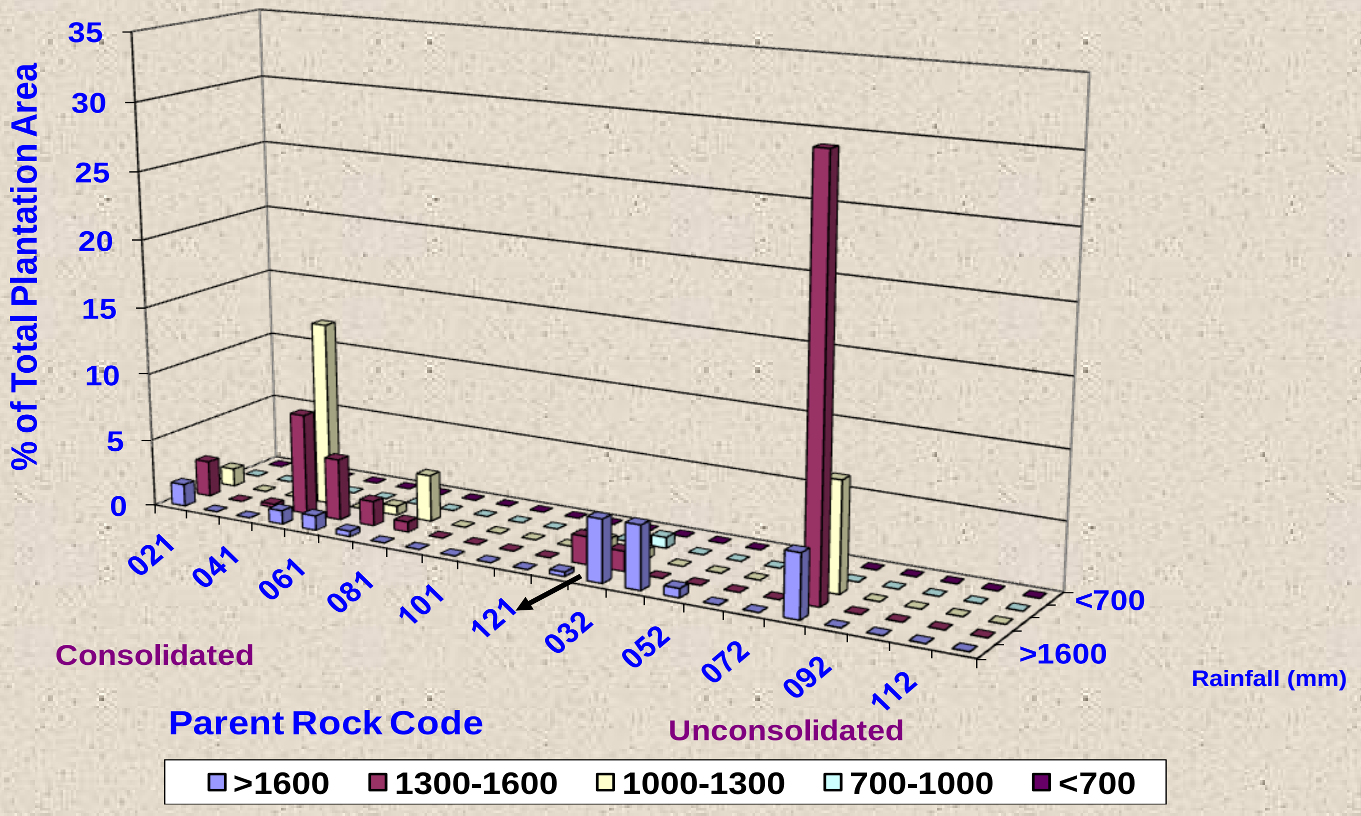
  - Parent Rock Codes (Soil Parent Material)– PRC
  - PRC either *in situ* or transported
  - Soil profile characteristics

- High variation in properties and tree growth

Australia - Radiata Plantations



New Zealand - Radiata Plantations



Methodology for Site Comparison

- **Direct yield comparisons.** Compare the yield of timber from compartments or blocks in different rotations.
- **Direct productivity comparisons.** Compare actual productivity of rotations (1R/2R or 1R/3R) using growth plots on the same location.
- **Productive Capacity comparisons**. Index of soil fertility. Is soil related to productivity or nutrient status?
- **Nutrient Budget analysis**. Nutrient input/output analysis.
- **Base line development.** Identification of baselines to evaluate productivity changes.


Northern Territory
Western Australia
Queensland
South Australia
New South Wales
Victoria
Tasmania

Radiata pine plantation on phosphate deficient site, Lidsdale S.F.

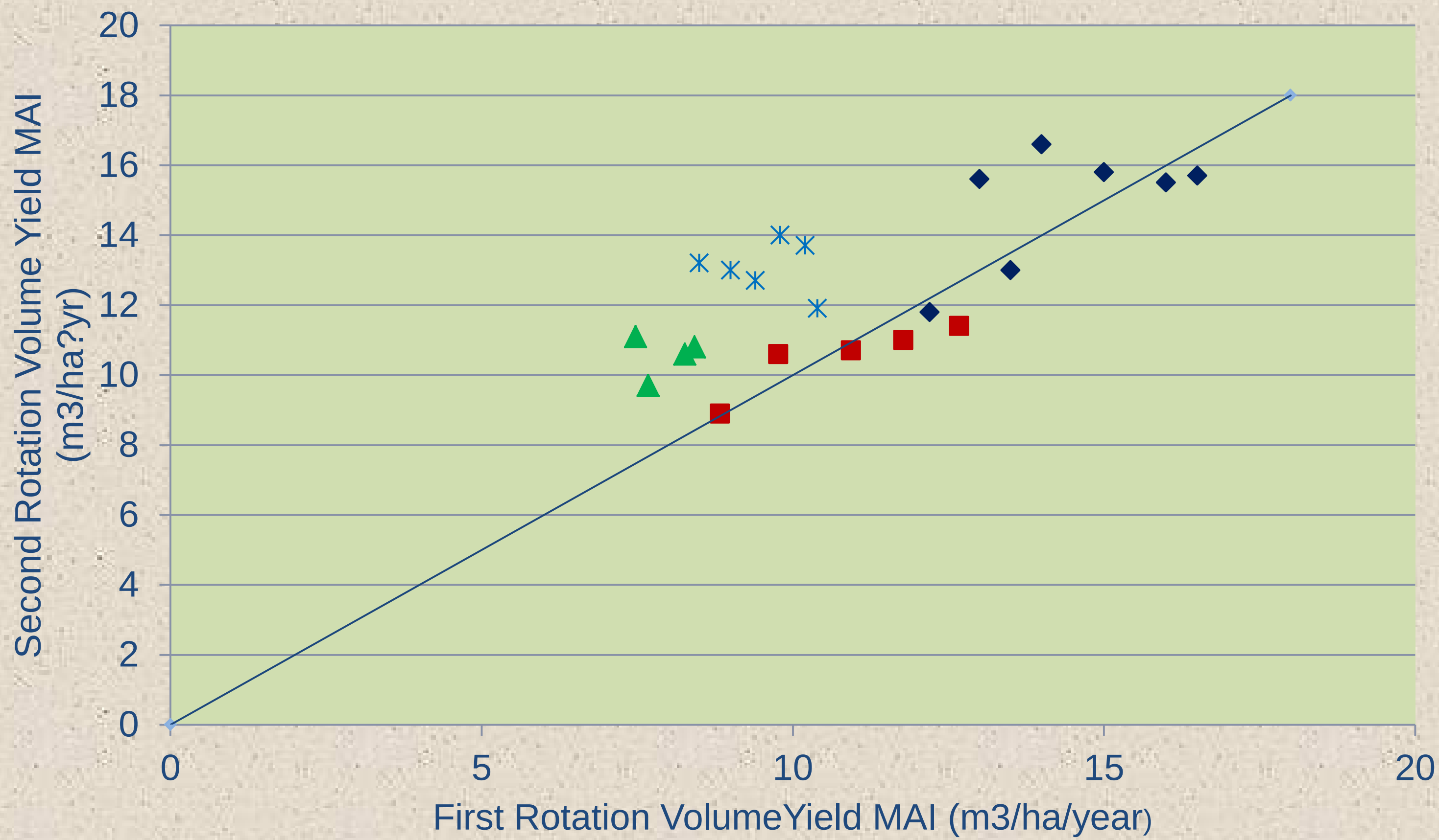
Soil developed from conglomerate, Lidsdale SF

Comparison of first and second rotation yield

Yield is merchantable timber expressed as mean annual volume increment (m^3/ha/yr)

Yield = (total volume of timber removed at final harvest (m^3) plus removals in thinning (m^3))
divided by compartment area (ha)
divided by rotation length (years)

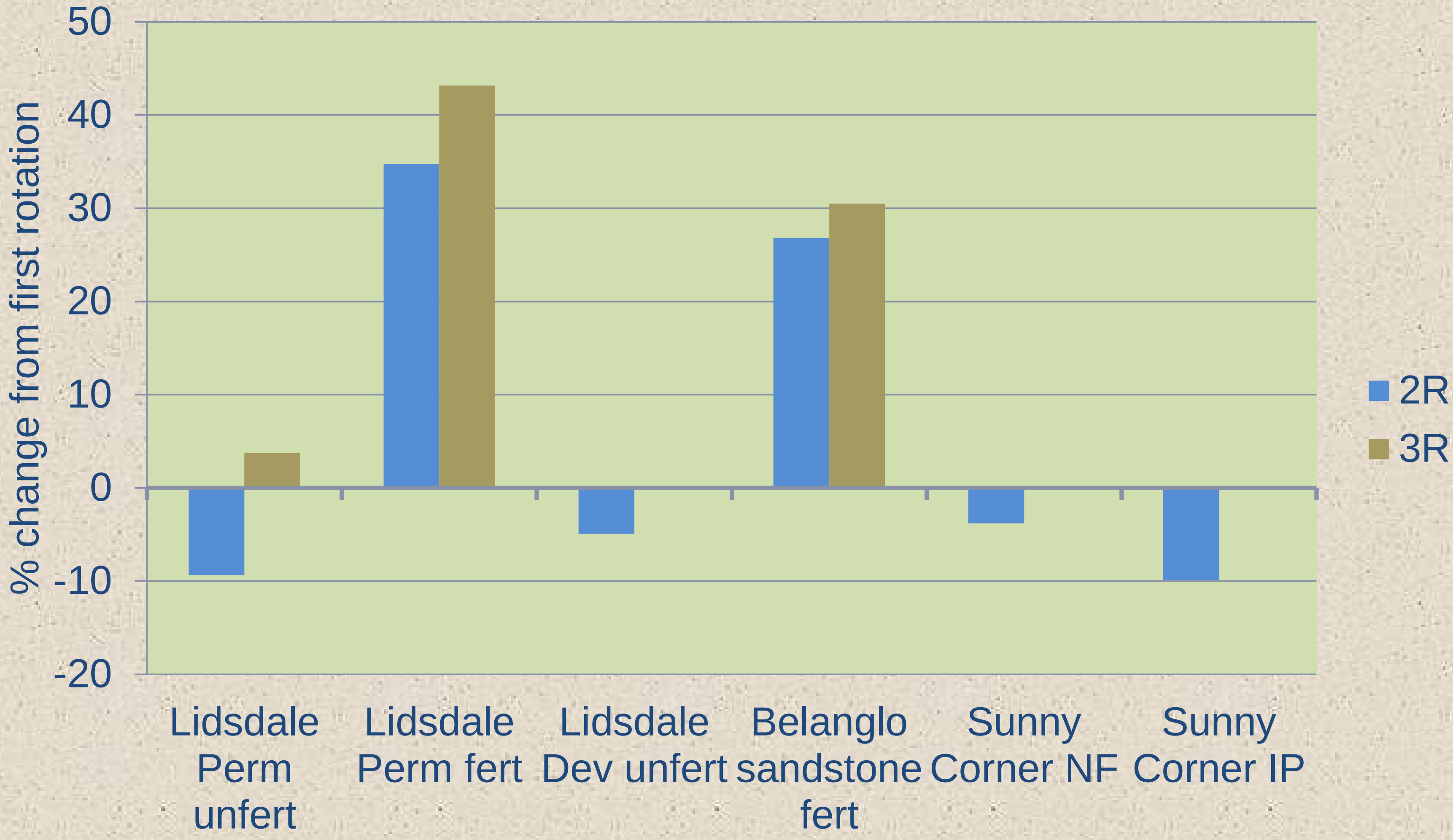
Compartment yields for first and second rotations



Comparison of first and second rotation productivity

- Productivity estimation plot based
- Plots on same location in 1R and 2R
- Re-measurement of diameters and height
- Application of same volume equations
- Productivity calculated as volume mean annual increment (m^3/ha/yr) at age 25 years and includes thinnings

Plot based productivity changes from first, second and third rotations



Productivity Conclusion

- Yield and productivity declines in 2R on sites where no major change in nutrients
- 3R generally higher than 1R
- Yield and productivity of fertilized 2R sites higher. Residual effect into 3R.
- High nutrient sites 2R productivity lower but yield higher than 1R (deformity factor)
- Early growth may not reflect long term growth

Soil Analyses

- Repeat sampling of soils at same points using same analyses or paired site sampling
- Compared concentrations and quantities (kg/ha)
- Used in soil-productivity models

Surface Soil Properties from Lidsdale S. F.

pH	total N	total P	Avail P	ex-Al	ex-Ca	ex-Mg	ex-K
	g/kg	mg/kg	mg/kg			me%	
Adjacent woodland							
4.75	0.55	117	1.7	1.3	1.65	0.61	0.27
First Rotation 1960 (30 year old)							
4.68	0.48	101	3.2	0.99	1.35	0.53	0.25
Second Rotation 2012 (34 year old)							
4.96	0.61	109	4.4	0.95	1.17	0.38	0.18

Relationship of soil factors to productivity

- Functions of productivity and soils based on 1R soils
- Applied to 2R soils to evaluate change
- Used quantity (kg/ha) to integrate soil depth data and allow assessment of losses or additions
- **Lidsdale nutrient quantities (50 cm soil depth)**

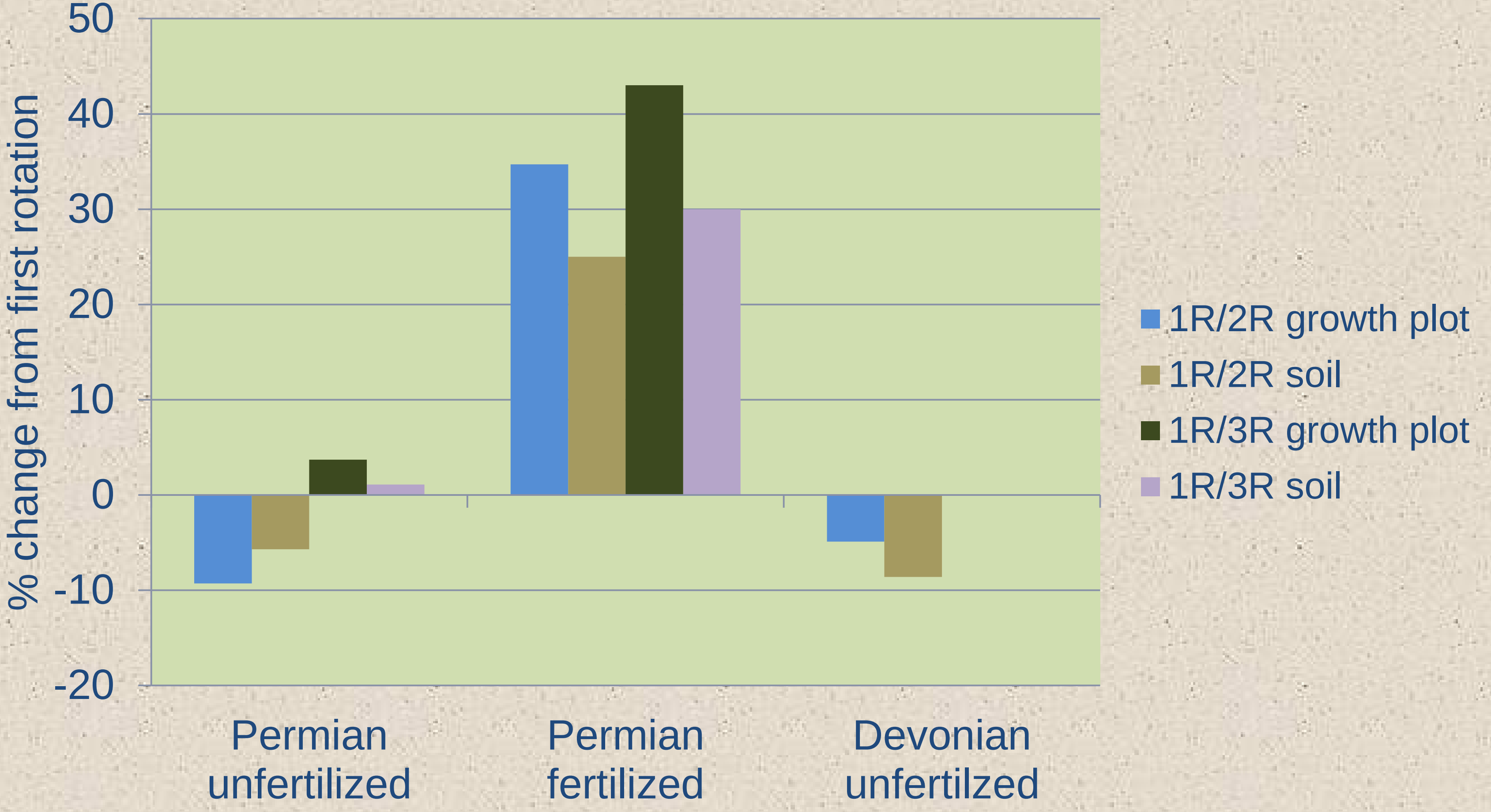
  MAI (m^3/ha/yr) =

  5.093 +
  0.00305*P(kg/ha) +
  0.0146*ex Ca(kg/ha) +
  0.107*ex K (kg/ha)

  R^2=0.763
  SE=1.803

- Long term loss by change in soil base cations

Measured growth plot comparisons and estimated from soil changes



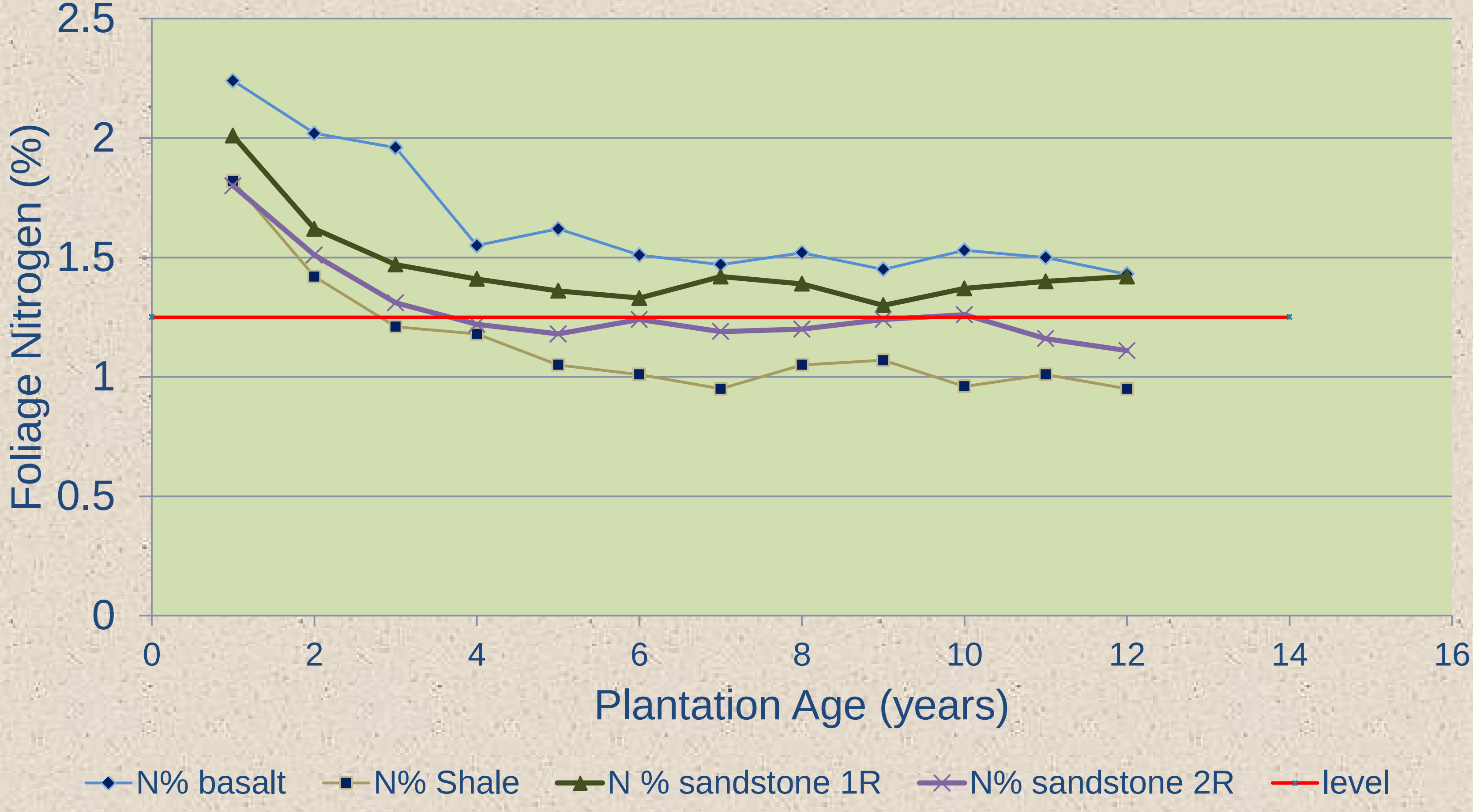
Conclusions on Soil Analyses

- Soils change over rotations
  - P changes due to fertilizer application
  - N declines at establishment may increase
  - Cations decline
  - Others change depending on site
- Soil/productivity relationships
  - Changes in productivity can be related to soil nutrient change
  - Early productivity appears related to N and P
  - Rotation length changes largely result of cation shift

Stand Nutrition

- Nutrition assessed by foliage nutritional status
- Basis for interpretation
- Nutrients change with:
    - stand age
    - site
    - management
    - environment

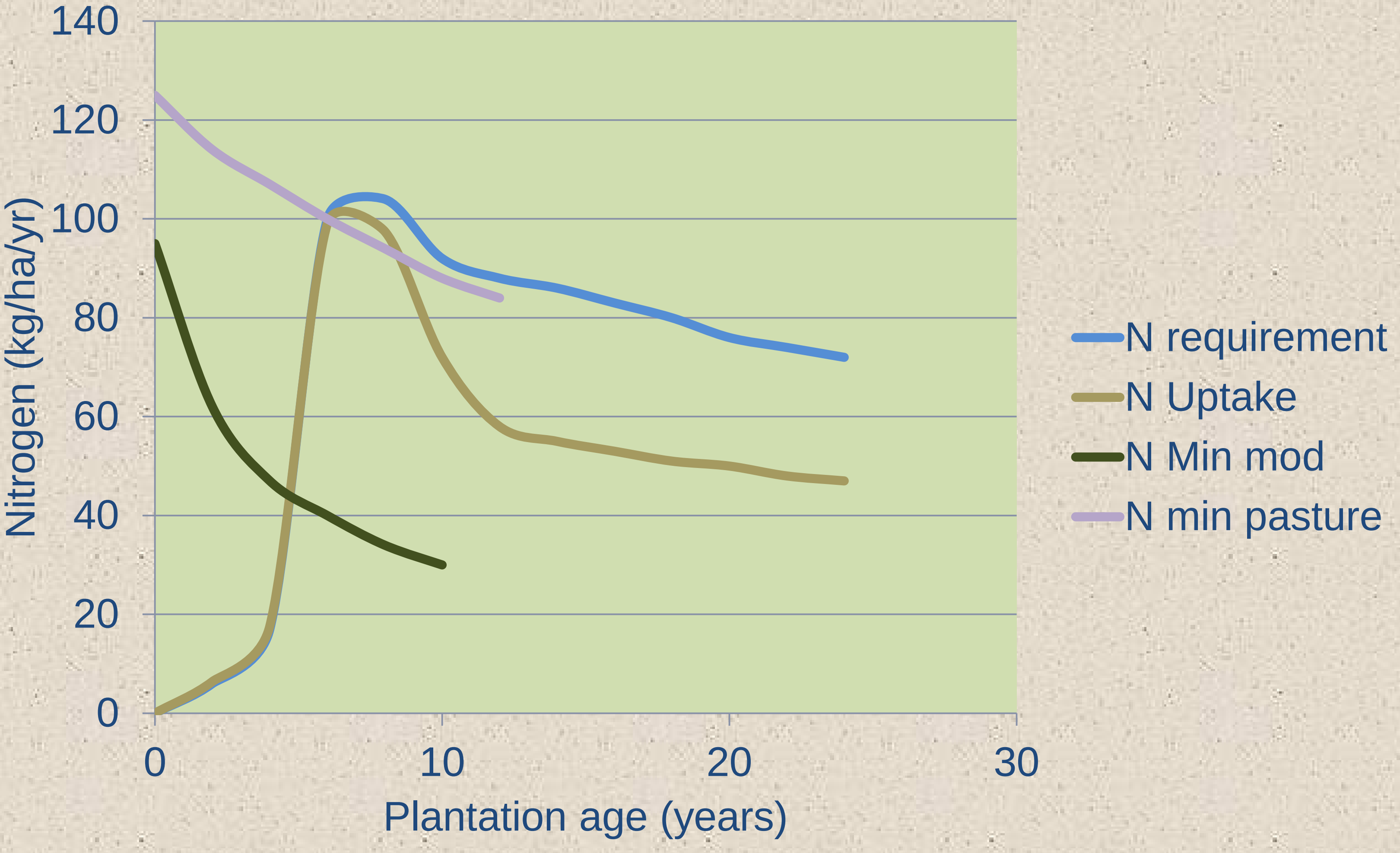
Foliage Nitrogen –Age and Site



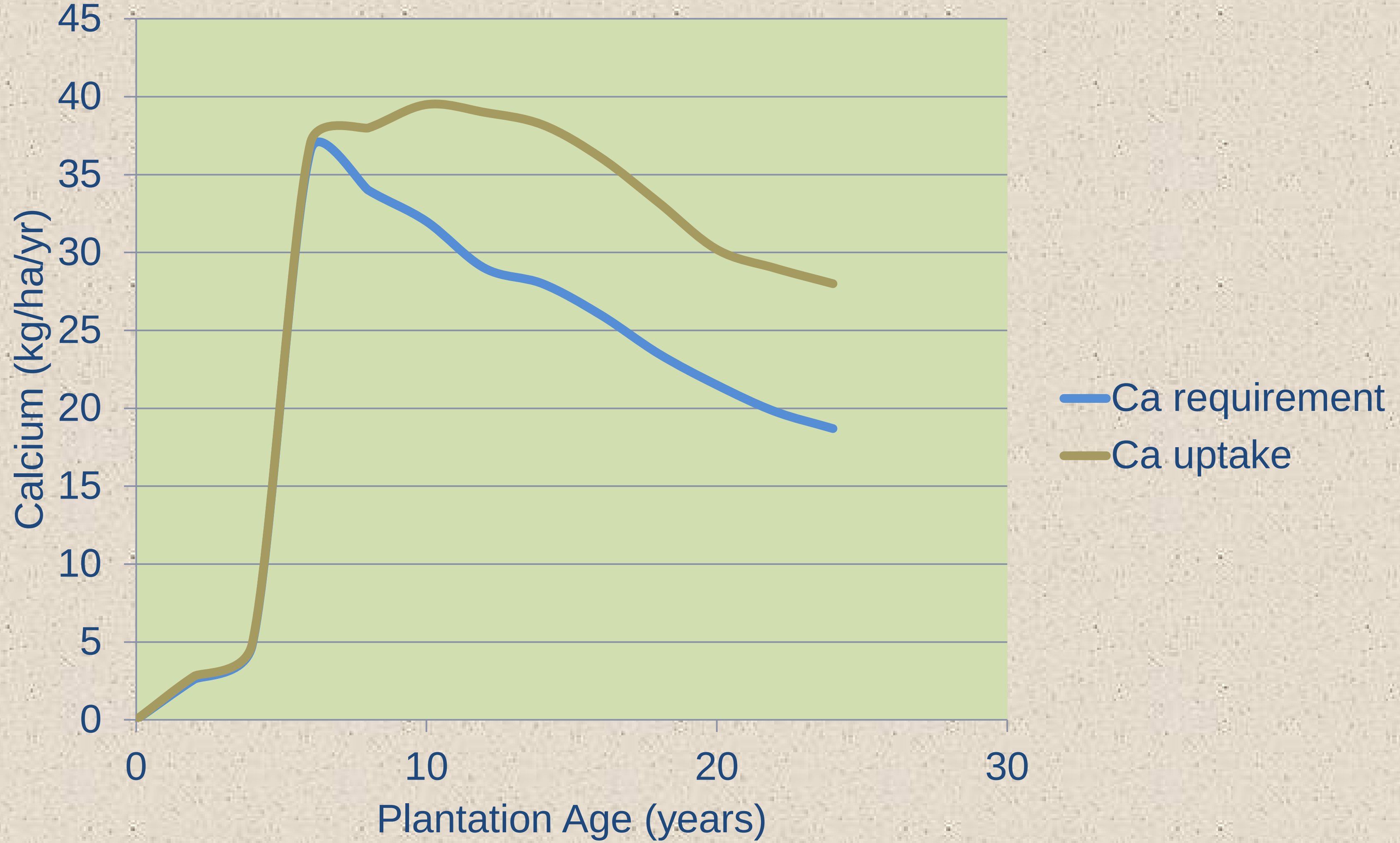
Foliage nutrient status of different rotations at different ages at Lidsdale

Age (years)	N (g/kg)			Ca (g/kg)			B (mg/kg)		
	1R	2R	3R	1R	2R	3R	1R	2R	3R
3	20.1	19.0	17.7	1.52	1.77	1.21	10.2	8.2	6.4
7	15.5	14.9	12.9	2.47	2.01	1.42	16.5	15.0	12.2
25	12.5	12.1	na	3.33	2.20	na	20.5	18.7	na

Nitrogen uptake and requirement with age



Calcium uptake and requirement with age



Types I and II Fertilizer responses and Type III depletion

CONCLUSIONS

- Changes occur in productive capacity between rotations
- Studies require multiple approaches
- Type and magnitude of change is related to site
- Early measured differences (1R/2R) not necessarily maintained through rotation
- Site differences indicate potential for classification into risk and identify risk factors for change

CONCLUSIONS (2)

- Nitrogen and phosphorus availability major factor in early stand development
- Calcium, potassium, magnesium and boron impact later even though not at apparently limiting levels
- Pool sizes based on site type major factors in long term productivity (proportional change)