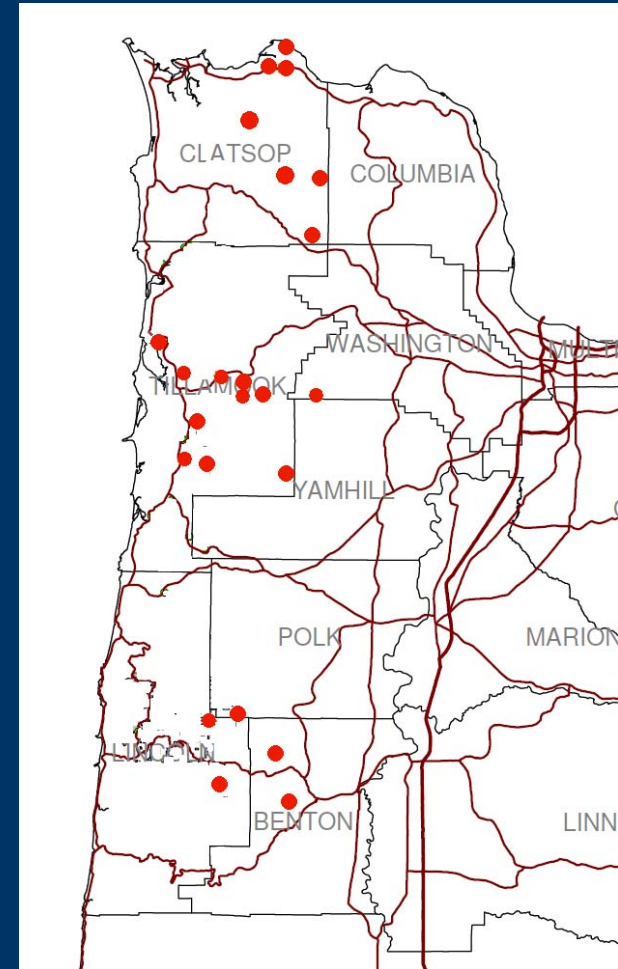


Outline

- **Pre-commercial thinning**
- **Commercial thinning**
- **Fertilization**
- **Fungicides**

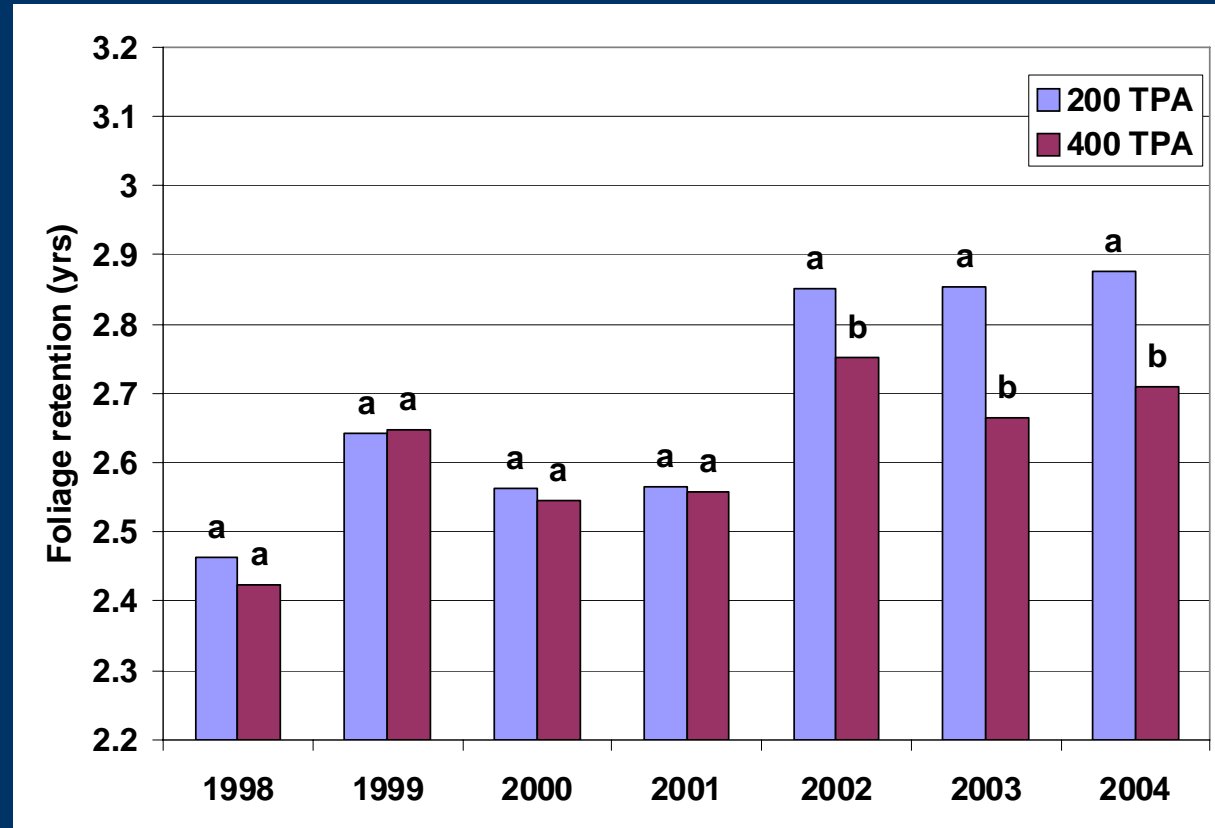
Pre-commercial thinning study

- Initiated in 1998
- 23 sites with thinned/unthinned plots
 - 21 sites have 200 TPA thinned plots
 - 5 of these also have 100 TPA sites
 - 2 sites have 100 TPA thinned plots
- Annual foliage retention assessments (1998-2004)
- Four remeasurements



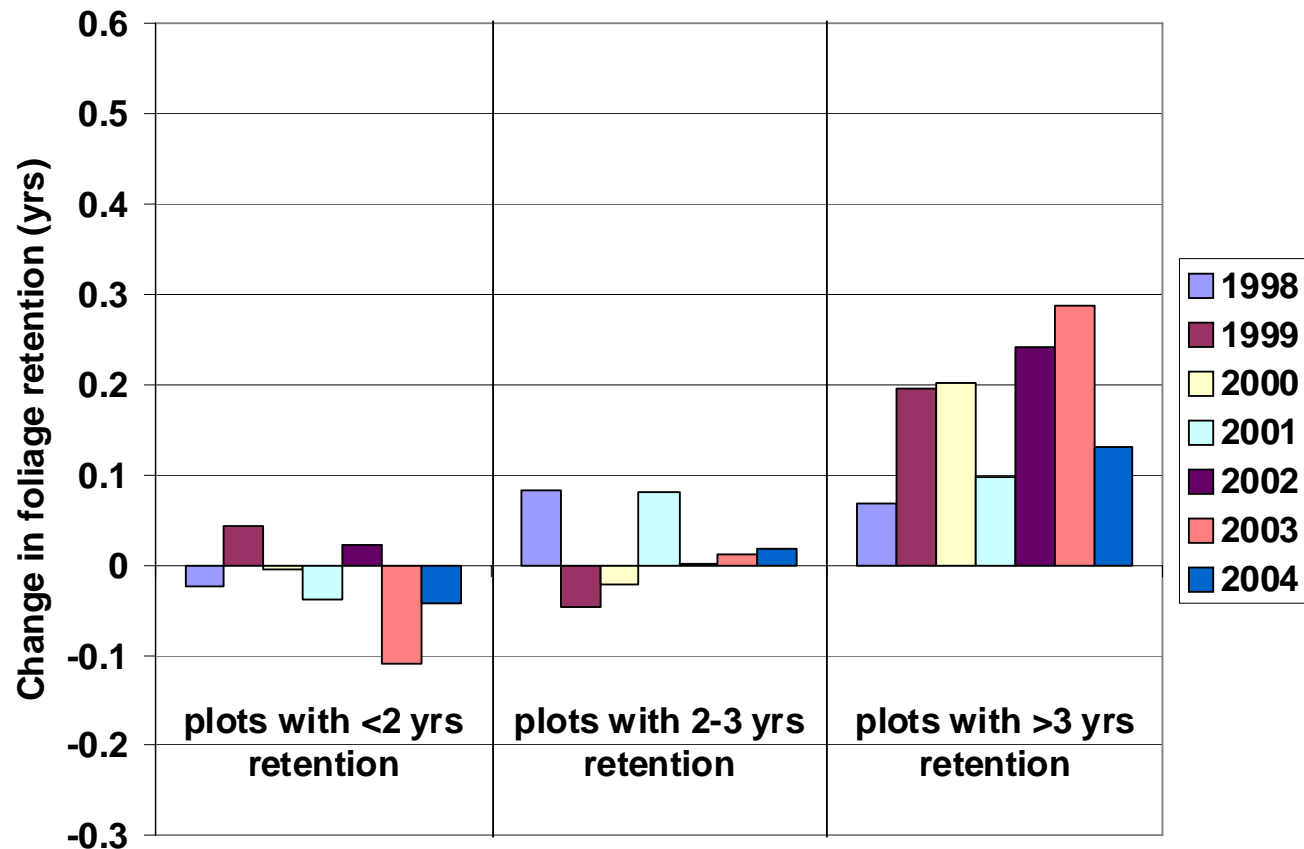
Pre-commercial thinning, whole crown foliage retention

- Whole crown foliage retention has increased following thinning



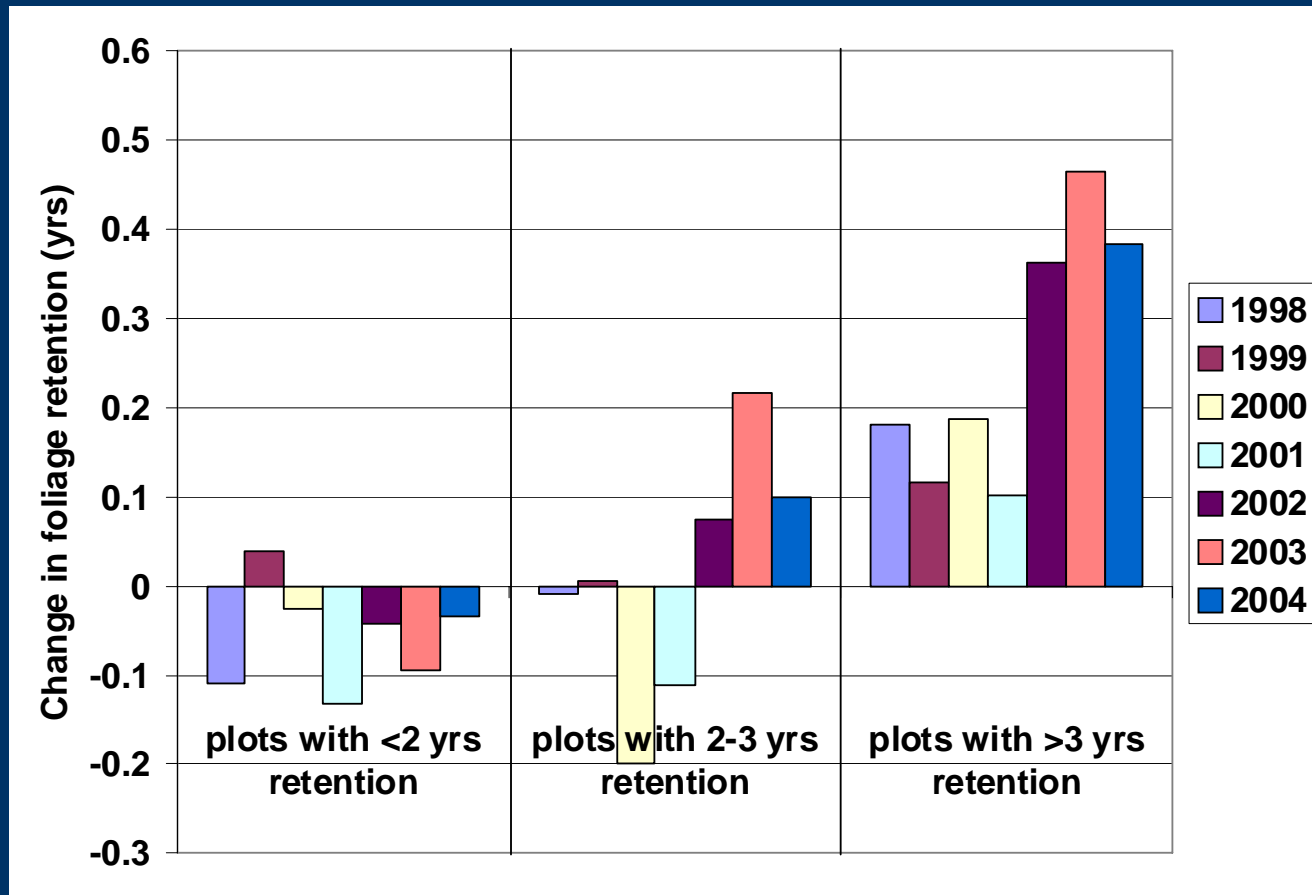
PCT, foliage retention, upper crown third

- Increases in foliage retention following thinning were limited to healthiest stands



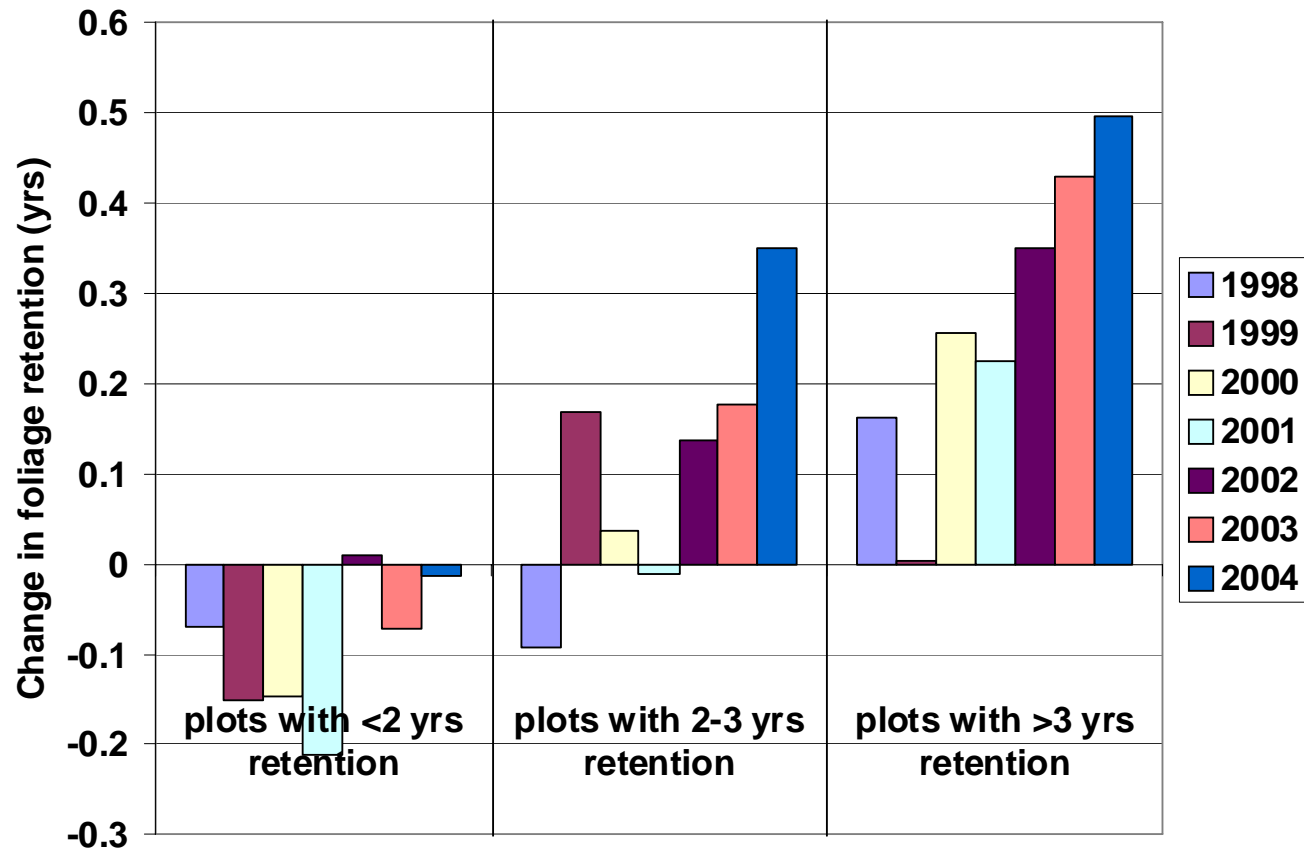
PCT, foliage retention, middle crown third

- Increases in foliage retention following thinning were limited to healthiest stands



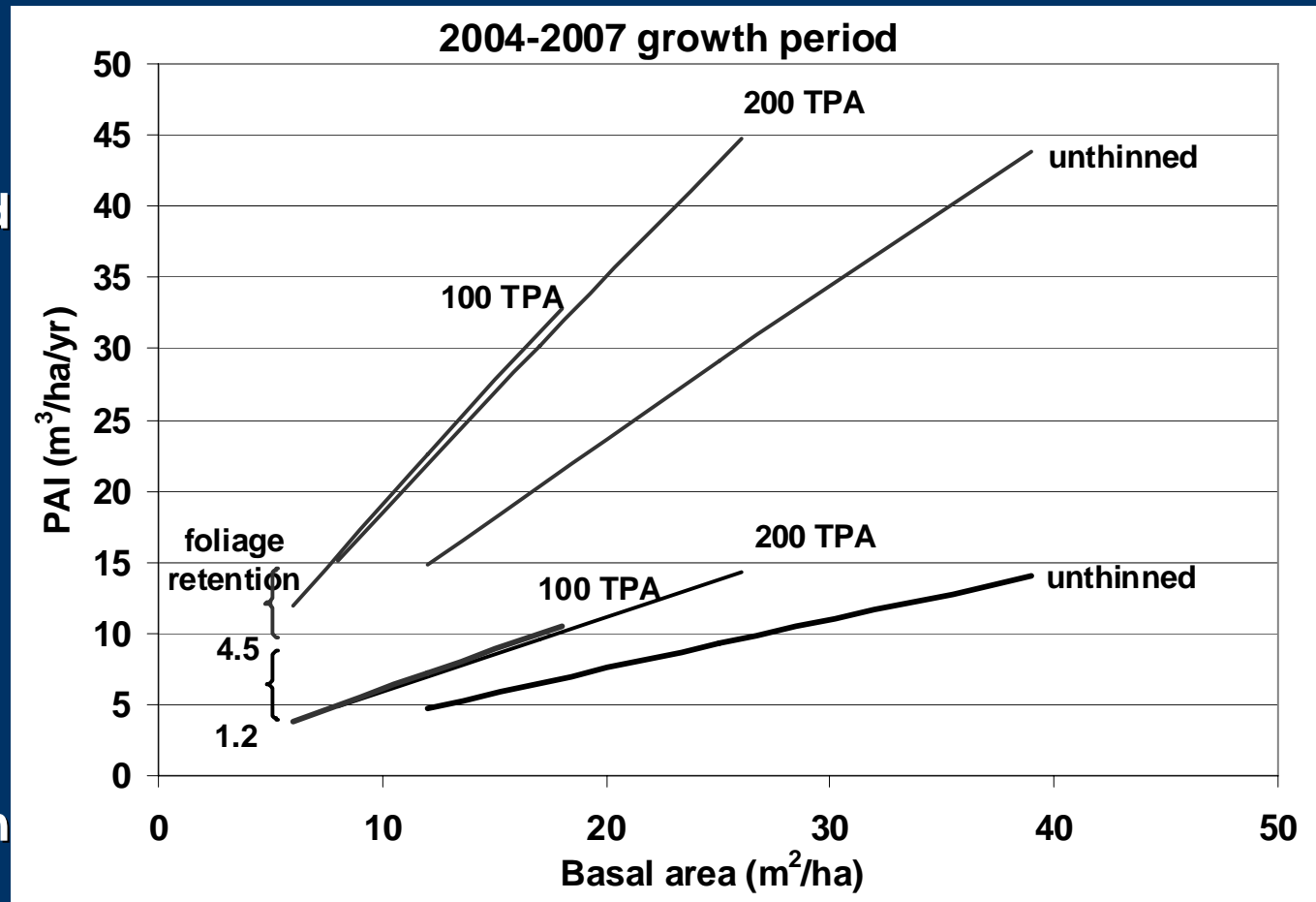
PCT, foliage retention, lower crown third

- Increases in foliage retention following thinning were limited to healthiest stands



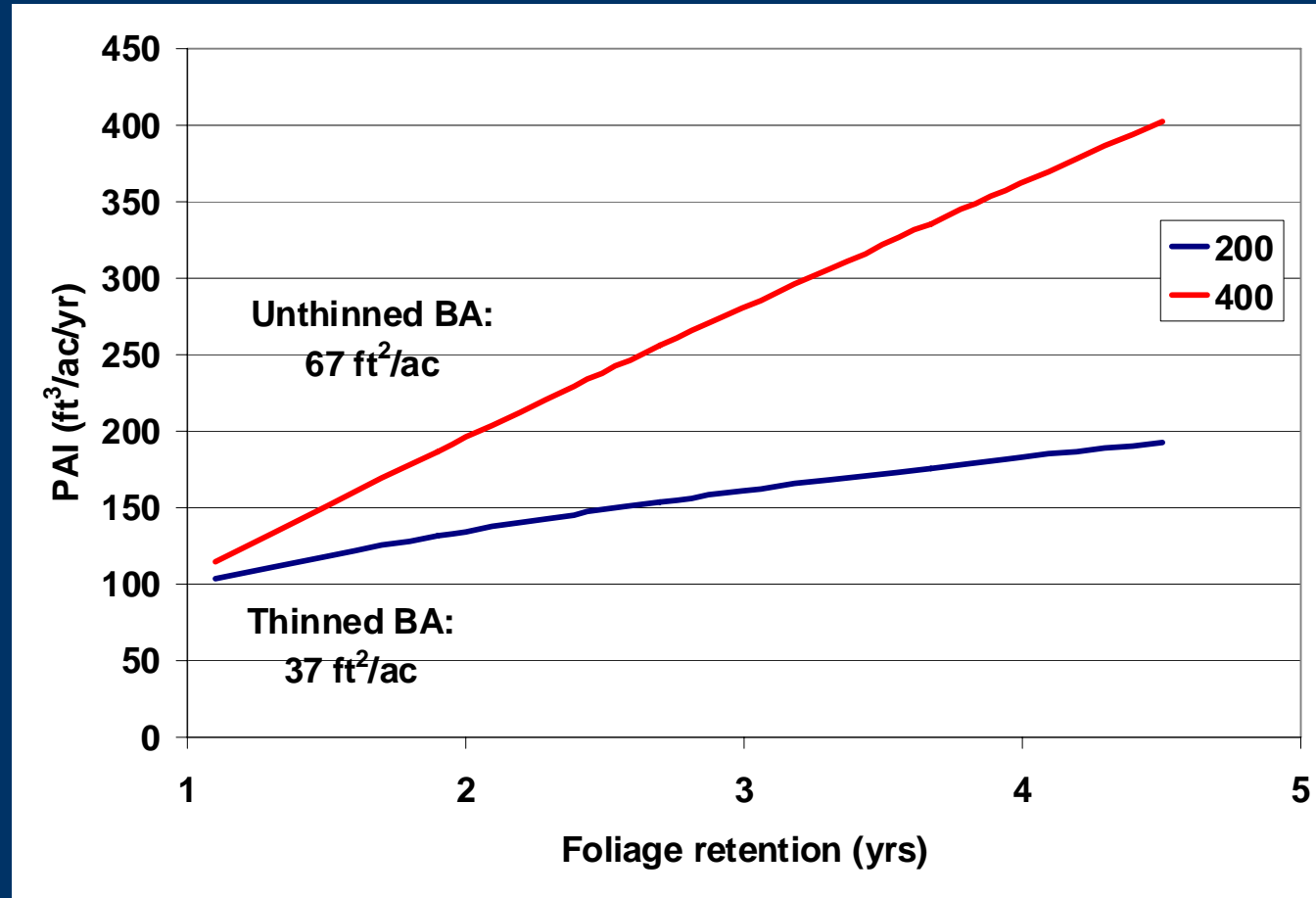
PCT, Growth

- Response to 200 TPA thinning has been consistent since 2000
- For given level of basal area, thinned stands growing ~50% faster
- Thinned stands produce same volume as unthinned stands with ~50% more basal area
- Currently no difference between 200 TPA and 100 TPA



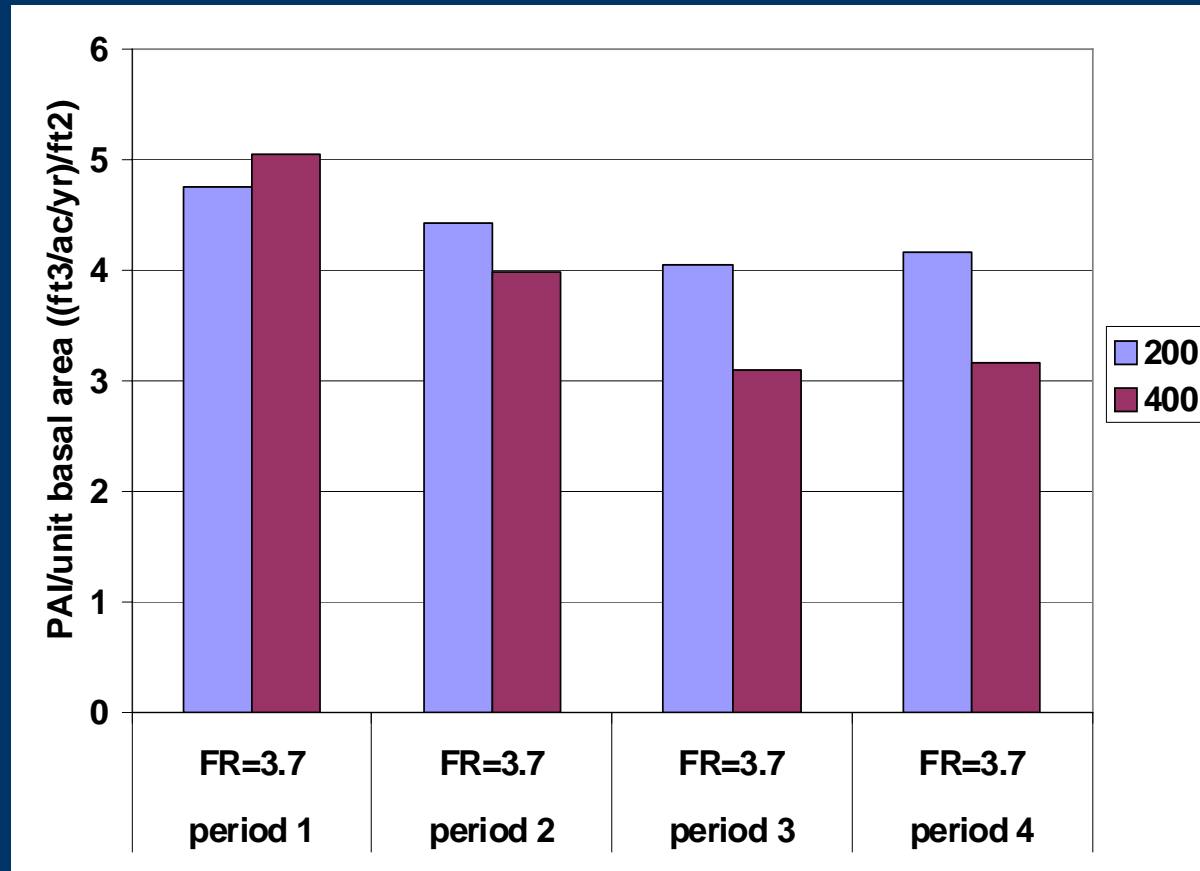
Period 1; 1-2 yrs post thinning

- Significant interaction between foliage retention and thinning
- Unthinned stands experiencing growth losses up to 71%
- Thinned stands experiencing growth losses up to 46 %
- Negative effect of foliage retention is smaller in thinned stands



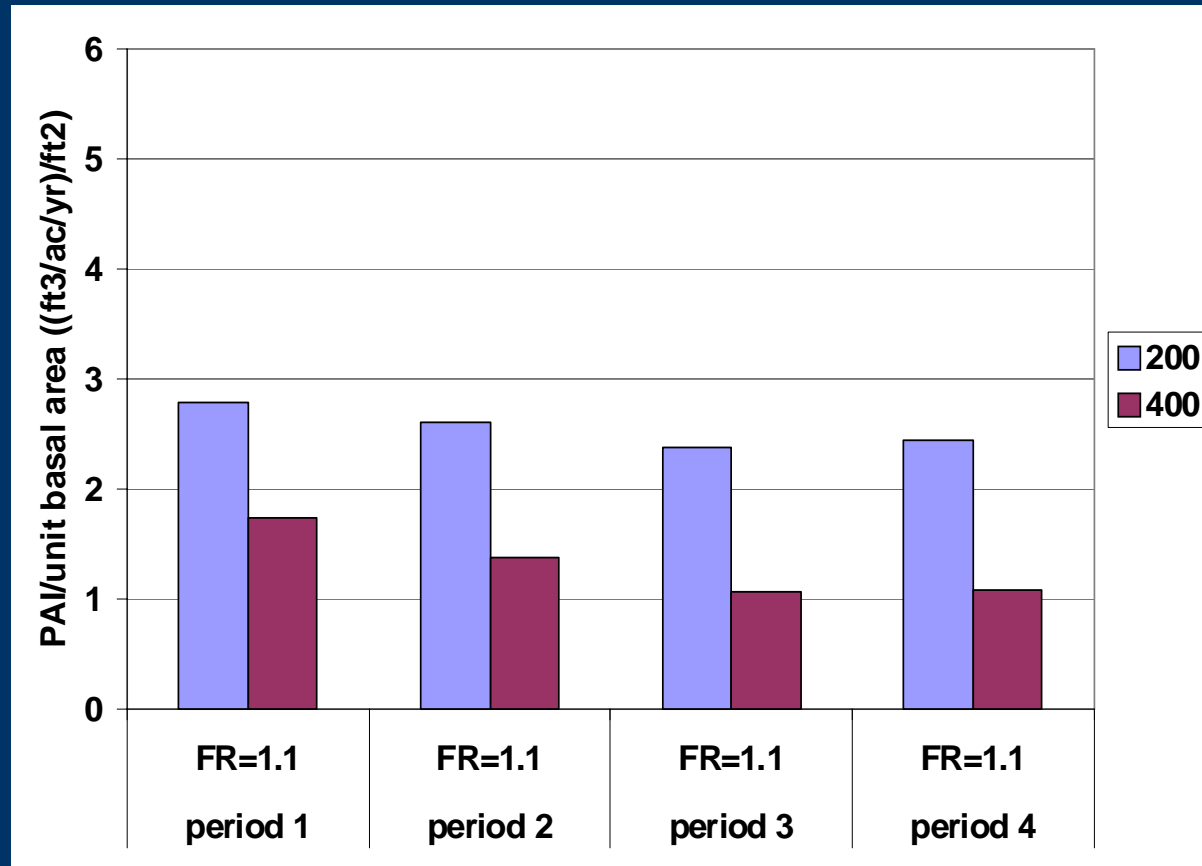
Growth per unit of BA

- Growth of healthy thinned stands is lower per unit basal area in period immediately after thinning



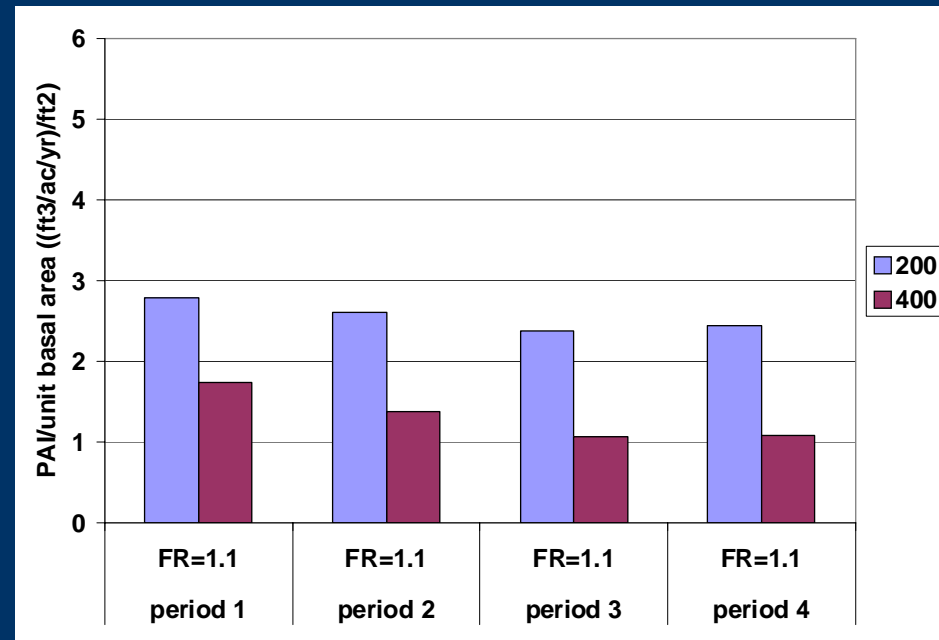
Growth per unit of BA

- Growth of infected thinned stands is greater per unit basal area in period immediately after thinning
- Why the difference between healthy and infected stands?



Growth per unit of BA

- Stands were thinned from below
- These young stands have always grown in presence of SNC
- Larger trees have demonstrated greater SNC tolerance
- Slow growth of small trees is partially the result of poor SNC tolerance
- Removal of small trees is getting rid of dead weight



PCT study, conclusions

- **Trees in infected stands will respond positively to thinning**
- **Stands should be thinned from below: largest trees have demonstrated a greater level of SNC tolerance than small trees**

Thinning in state forests

- **Swiss needle cast epidemic has been particularly bad around Tillamook**
- **State owns thousands of acres of 30-50 year old Douglas-fir in Tillamook state forest**
- **State is interested in creating structurally diverse/complex stands, which requires thinning to reach management objectives**

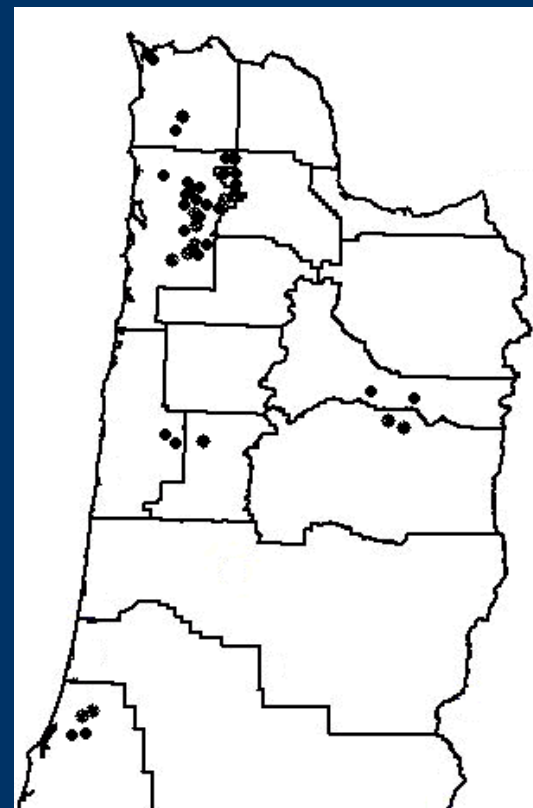
ODF Commercial thinning study

- **Phase 1: Retrospective**

- plots thinned 4-10 years prior to establishment
- 45 plots established in 2002 and 2003
- 42 remeasured after 4 yrs

- **Phase 2: Permanent**

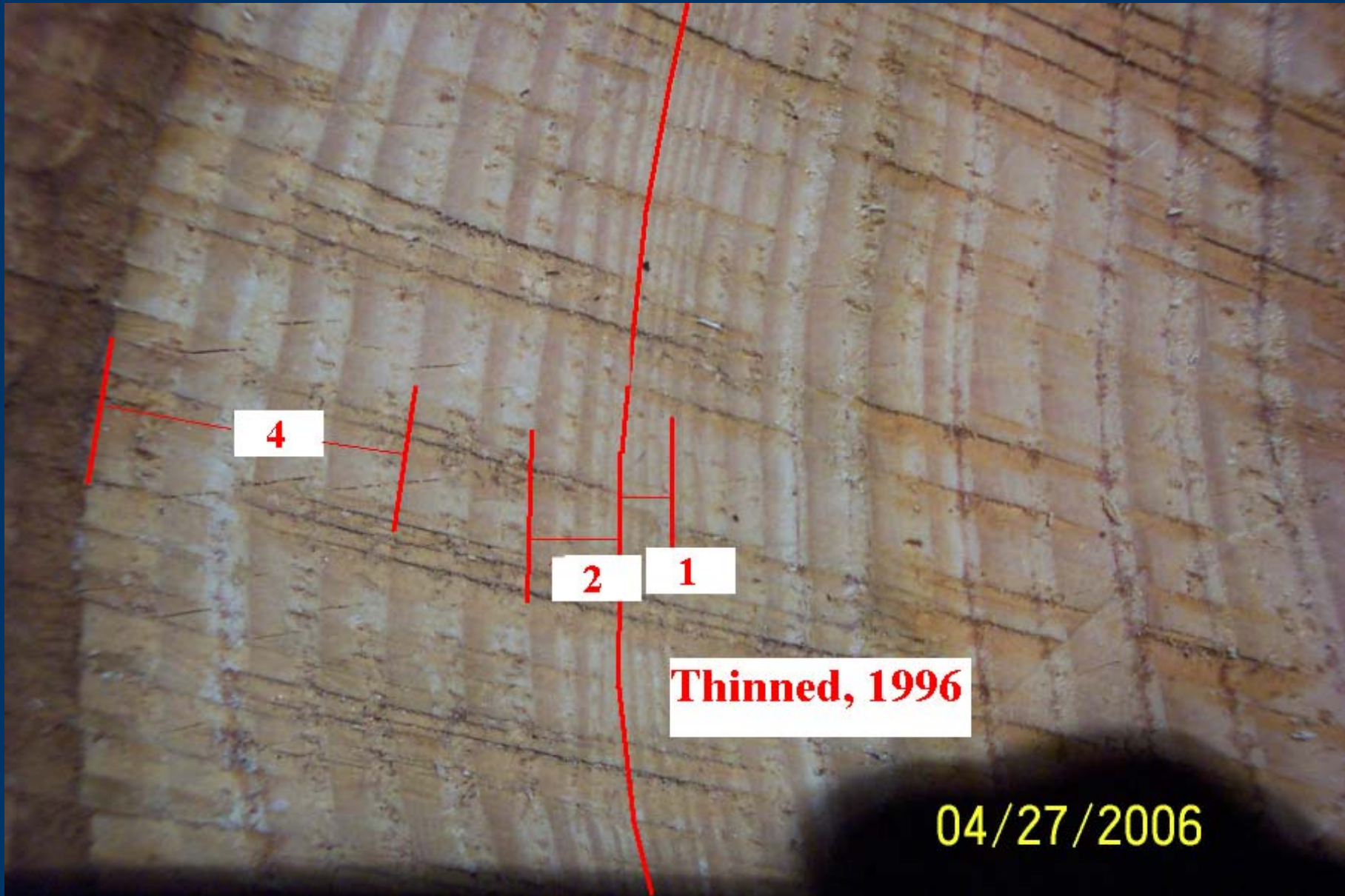
- Thinned after establishment
- 30 paired plots established; 15 in 2002 and 15 in 2003
- Both groups of 15 pairs have been remeasured for two 2-year growth periods



Outline of results

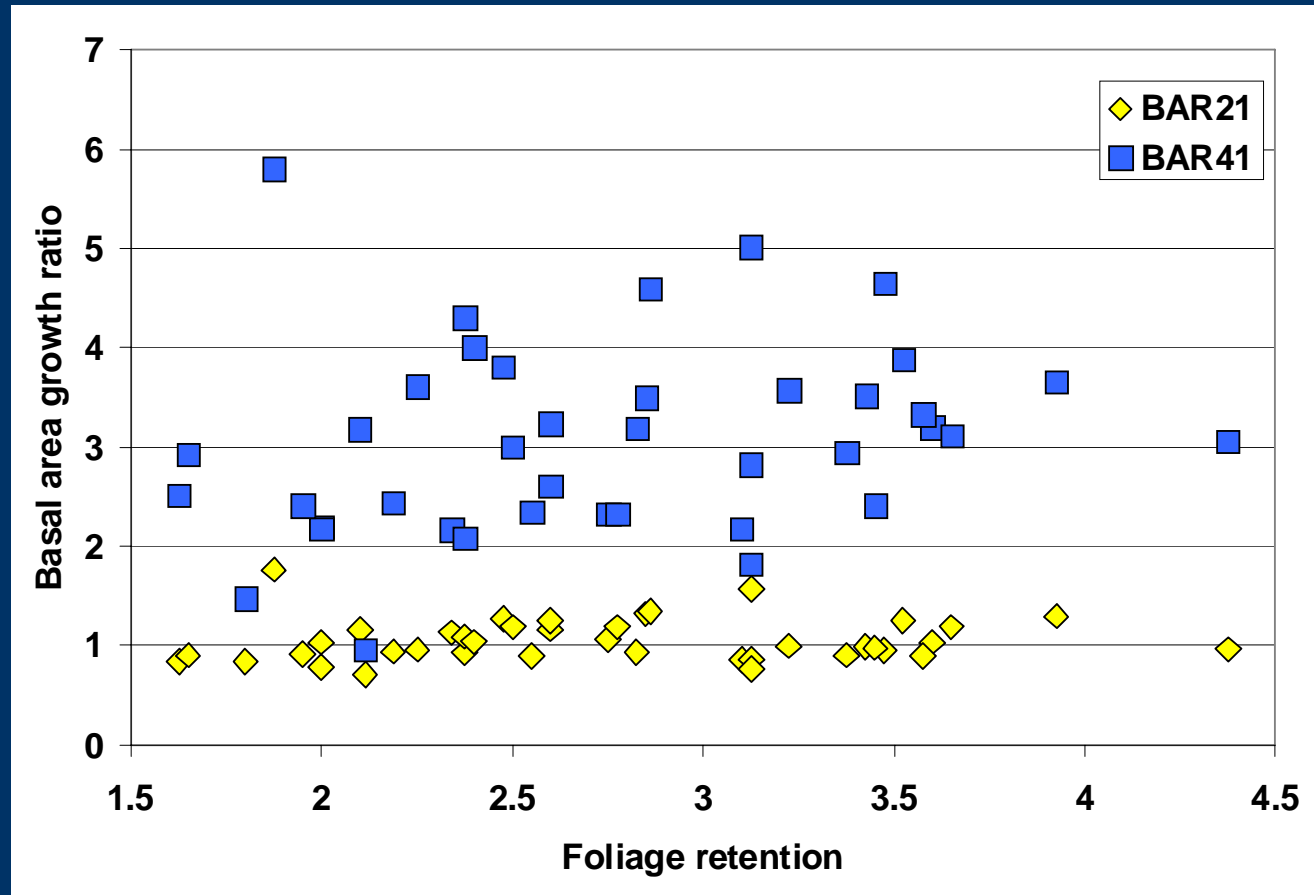
- **Retrospective**
 - Basal area growth
- **Permanent**
 - Change in foliage retention
 - Volume response (stand and individual tree)

Retrospective, Basal area growth ratio



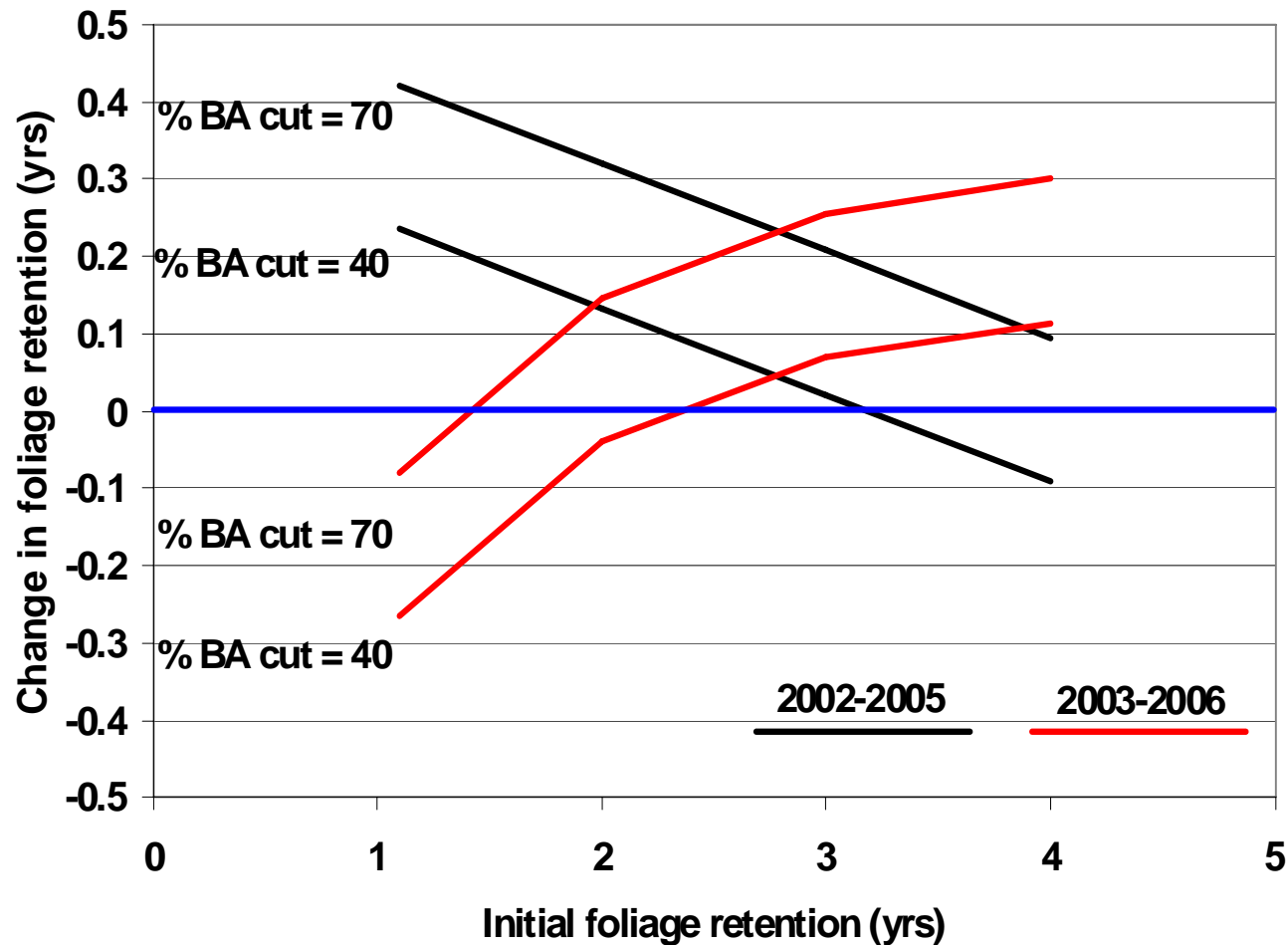
Retro, Basal area growth ratio

- Minimal response differences between healthy and infected plots (BAR21)
- All plots responded to thinning (BAR41)
- Basal area growth in last 4 years is still accelerating



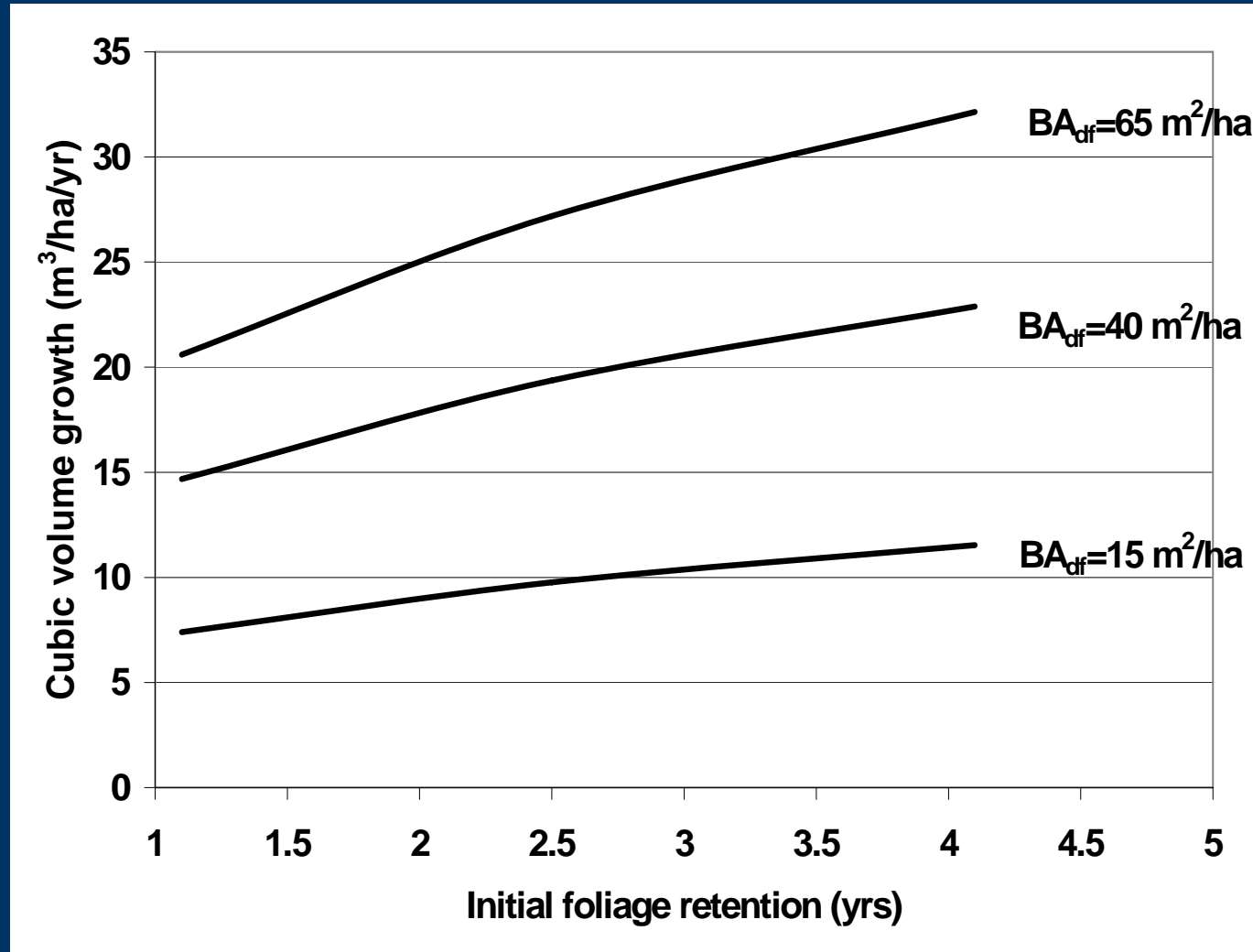
Permanent plot pairs change in foliage retention

- Thinning improved foliage retention
- Change in foliage retention depended on growth period
- Changes in foliage retention small in relation to measurement error



Perm, stand level PAI (volume)

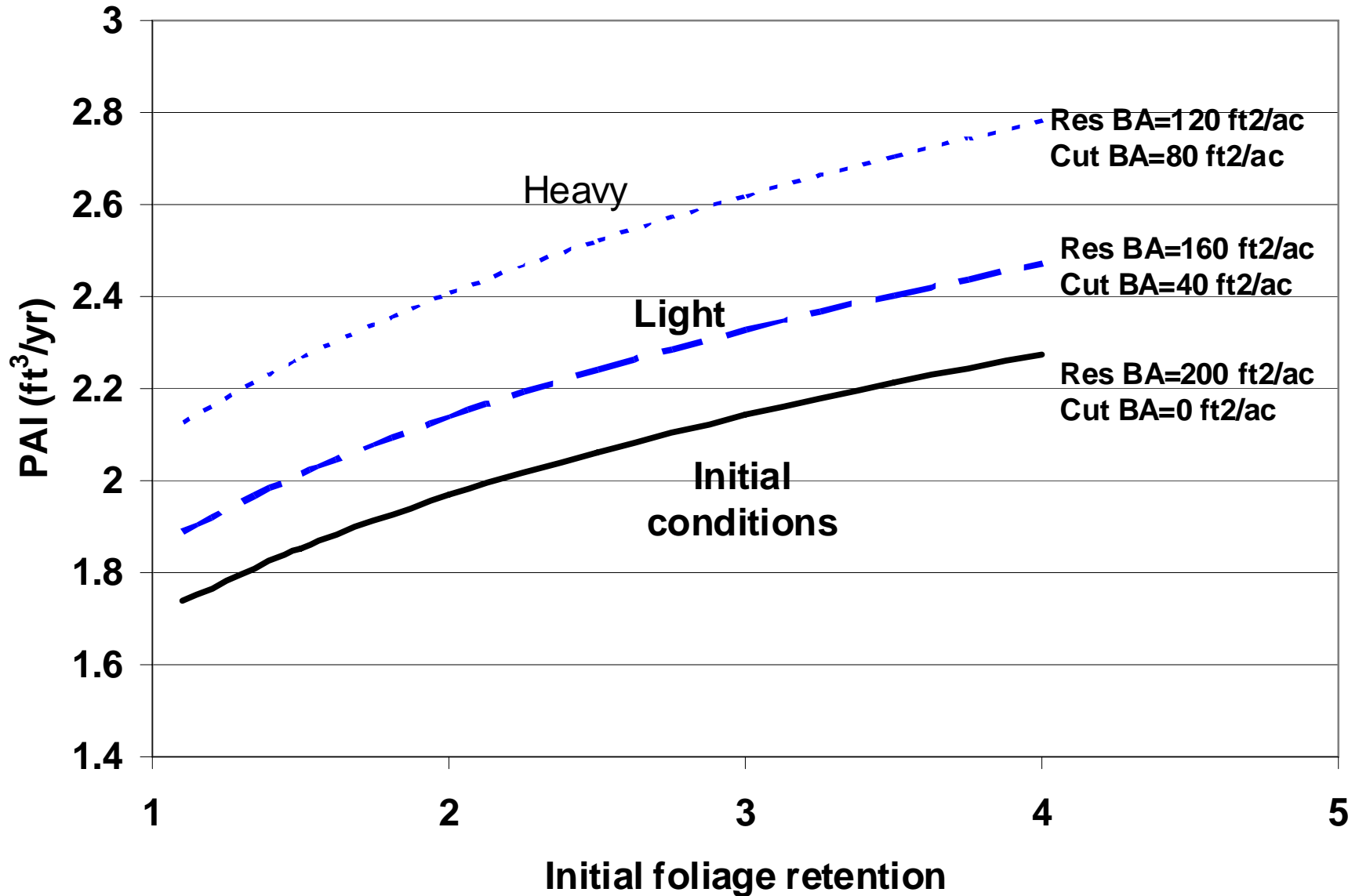
- Volume growth depends on DFBA, FR, and age
- Growth losses in the most heavily infected stands ~35%



Perm, tree level PAI (volume)

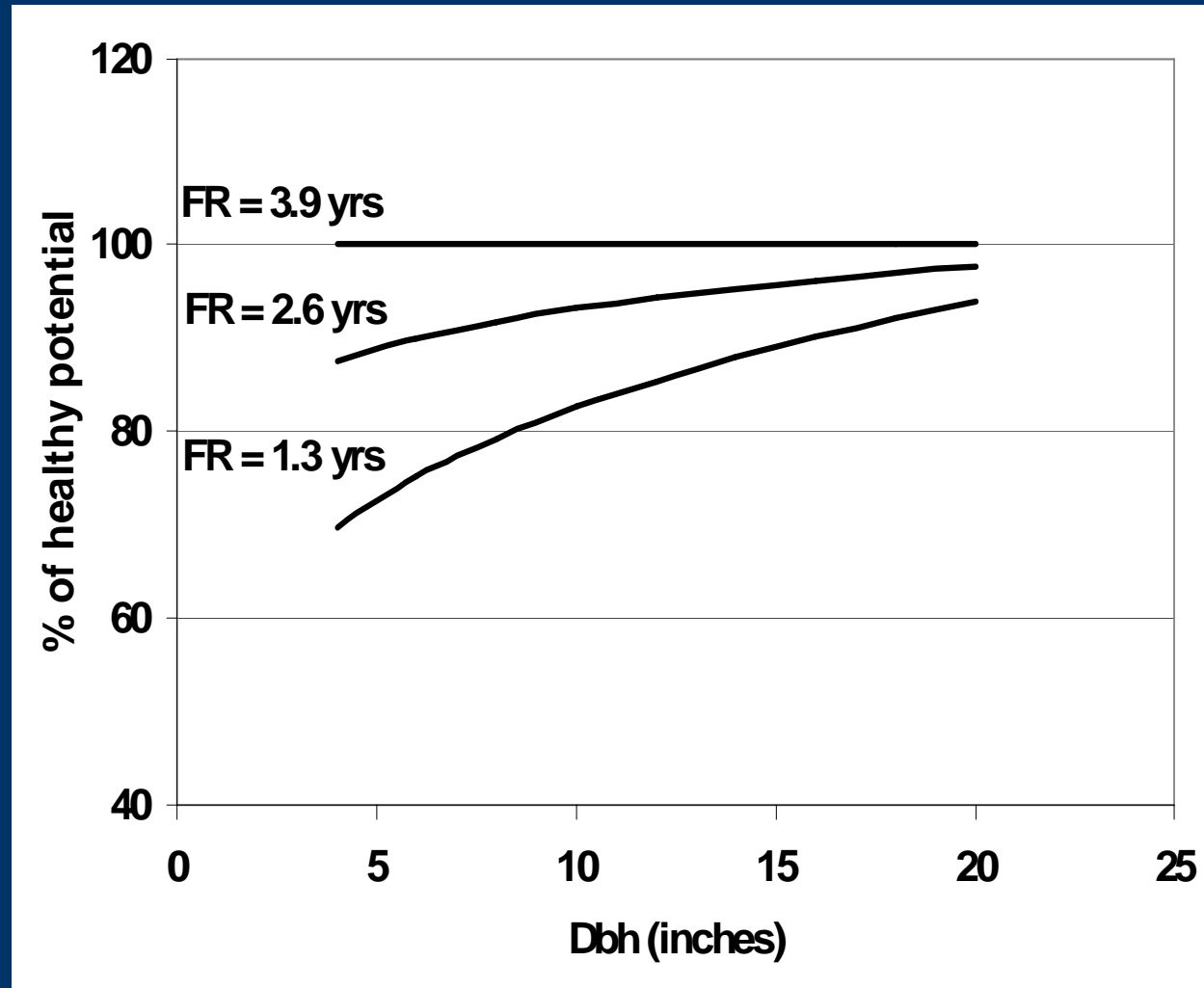
- Removing basal area had a negative effect on residual tree volume growth
- Lower stand density had a positive effect on residual tree volume growth
- Thinning had a positive impact on tree growth; positive effect of lower stand density is larger than negative effect of removing basal area

Tree level PAI (light vs. heavy thin)



Effects of thinning, tree level

- Larger trees maintain a larger percentage of their healthy growing potential than smaller trees
- Thinning from below increases proportion of trees that grow well in the presence of SNC

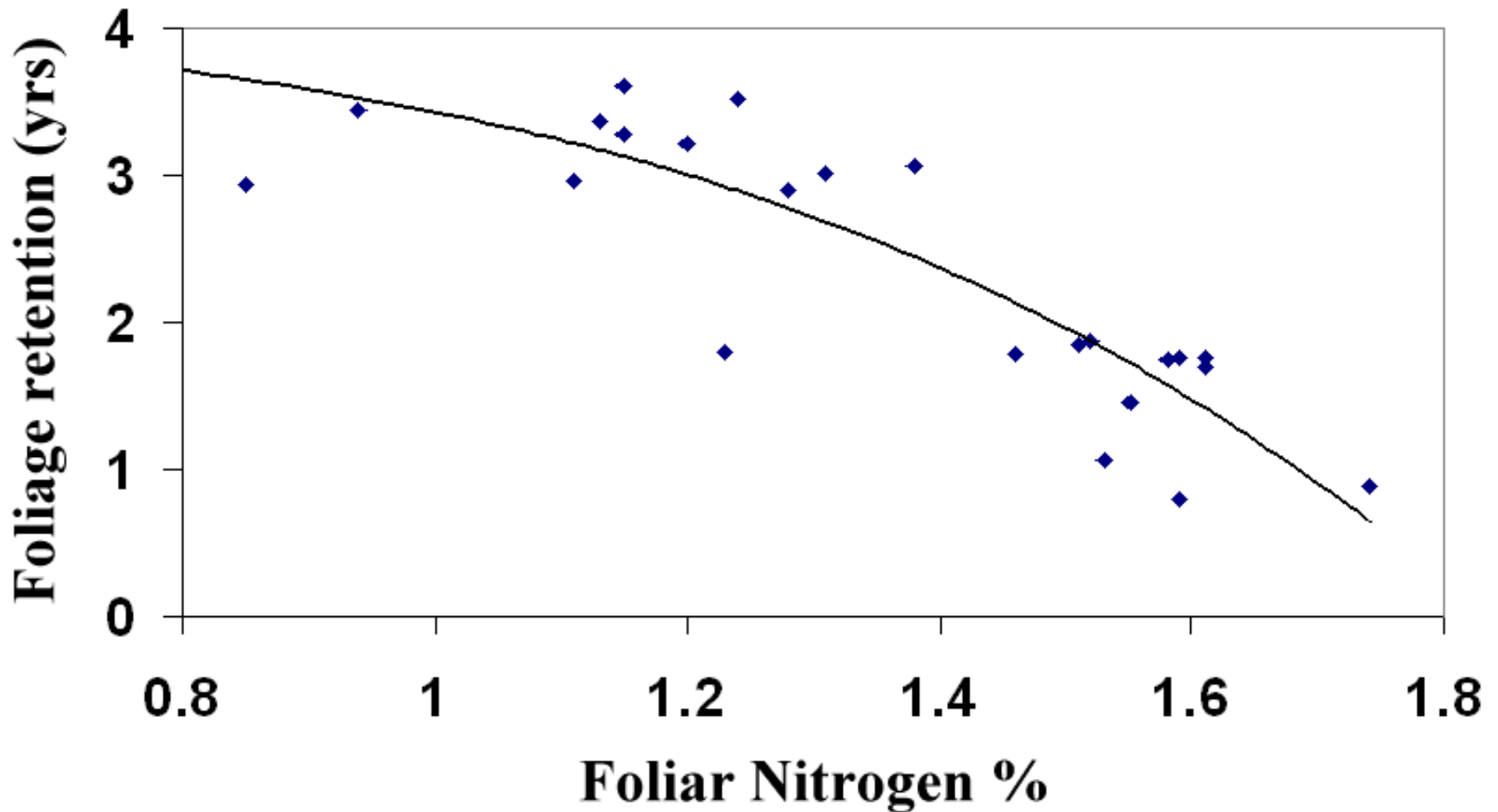


Conclusions

- **Volume growth of SNC-infected trees will improve following thinning**
- **Changes in foliage retention are small in relation to foliage retention measurement error**
- **Changes in foliage retention appear to be driven more by year to year SNC variation than by thinning**

Fertilization

Background



Background

- **SNC Coop studies suggest that nitrogen may be ineffective (or worse) in SNC-infected stands**
 - **Lack of response to N in previous fert trials**
 - **Negative correlation between foliage retention and foliar N**
 - **N from fertilization was found to be directly responsible for increased fungal nitrogen levels and fungal fruiting, and thus, disease severity**

Beyond N Fertilizer trials

- **Trials initiated in Summer of 2006, with participators able to test 5 or 7 treatments**
 - **No treatment control**
 - **Nitrogen**
 - **Calcium (Lime)**
 - **Calcium chloride**
 - **Phosphorus**
 - **2 Site specific blends**

Beyond N Fertilization Trials

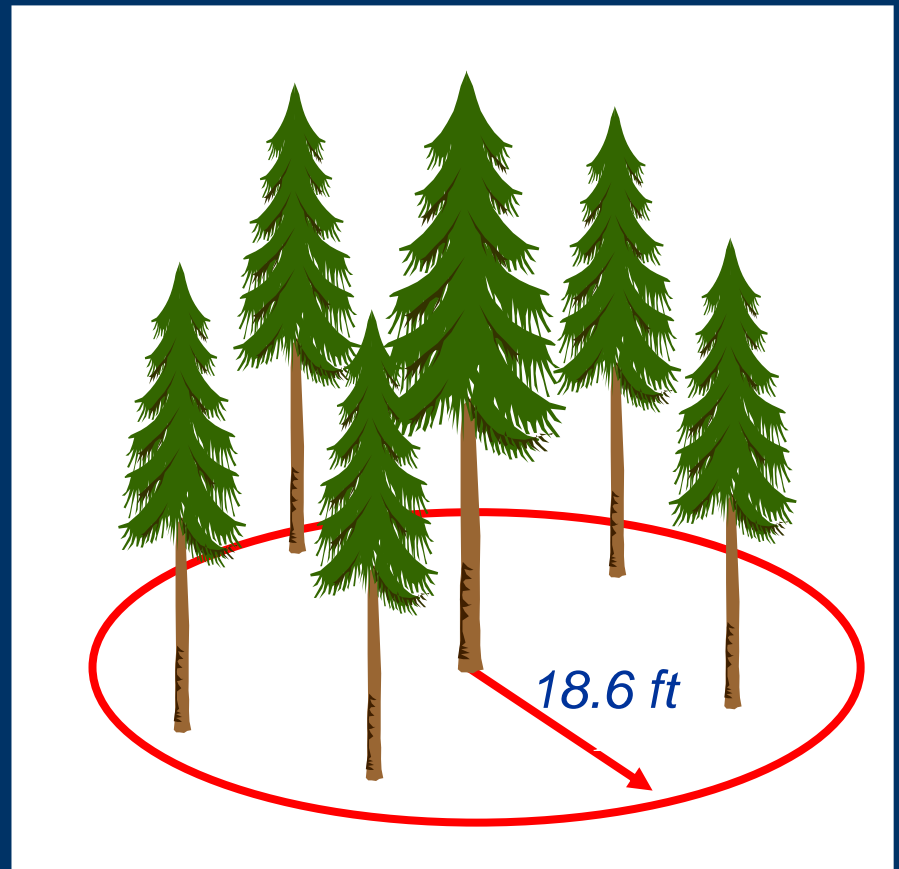
16 locations, 10 landowners

Cascade Timber
Giustina
Hampton (2)
Lone Rock
Campbell Group (2)
ODF
OSU
Port Blakely
Starker Forests
West Fork Timber
Weyerhaeuser (2)



Study design

- Individual tree plots (1/40th acre)
- Centered on subjectively chosen dom/codom tree
- 5, 7, or 8 treatments per site
- 10 plots per treatment
- 50, 70, or 80 plots per site



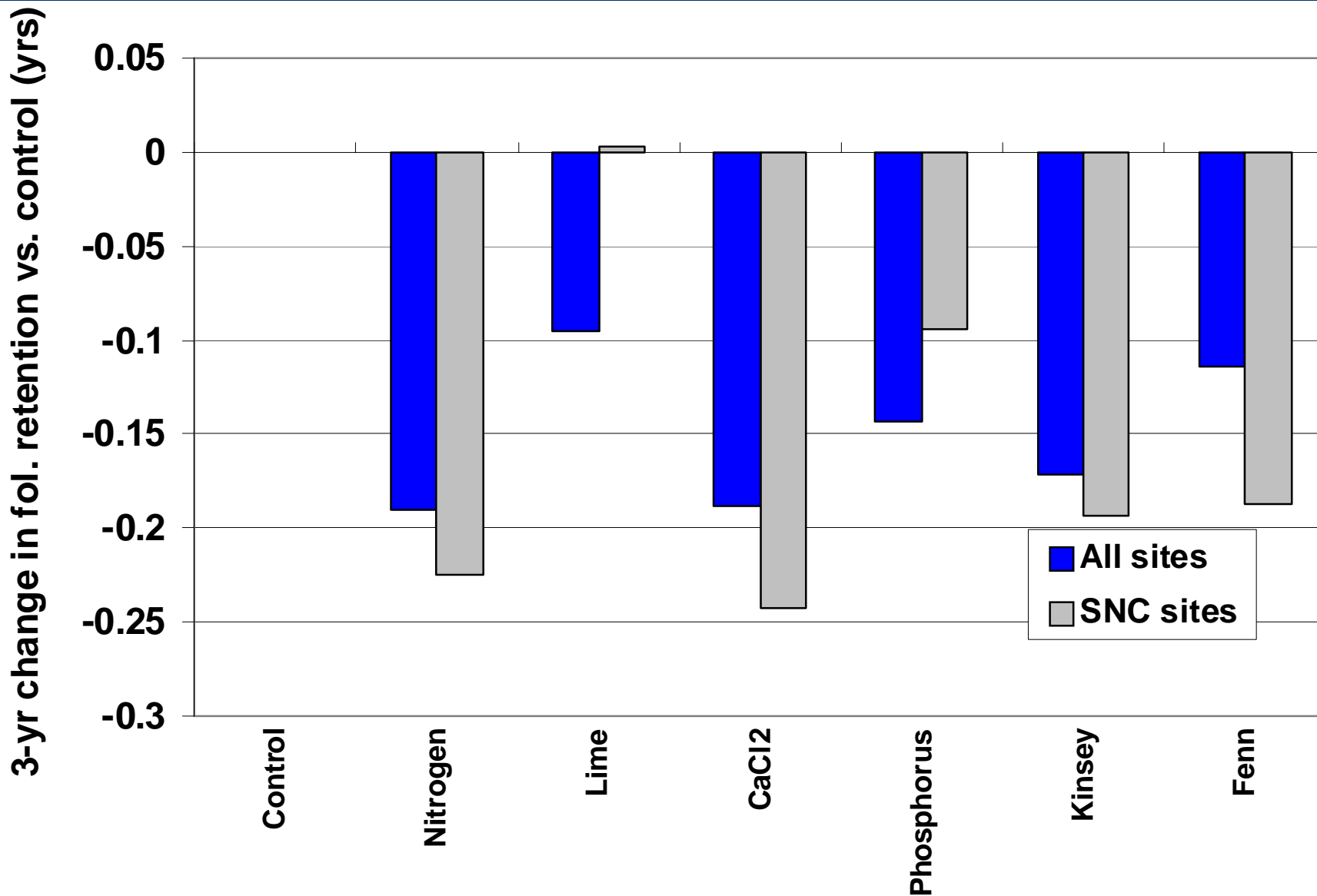
Target stands

- **Target stands**
 - Nitrogen rich
 - 20 yrs of age (+/- 5 yrs)
 - 300 tpa (+/- 100 tpa)
 - No pct or fertilization in last 8 years
 - < 20% salal cover

Treatments

Treatment	Form	Amount
Control	--	--
N	Urea	200 lbs N / ac
Lime	CaCO ₃	900 lbs Ca / ac
Ca	CaCl ₂	90 lbs Ca / ac
P	NaH ₂ PO ₄	500 lbs P / ac
Kinsey	Blend	Site specific
Fenn	Blend	Site specific

Change in foliage retention



Change in foliage retention

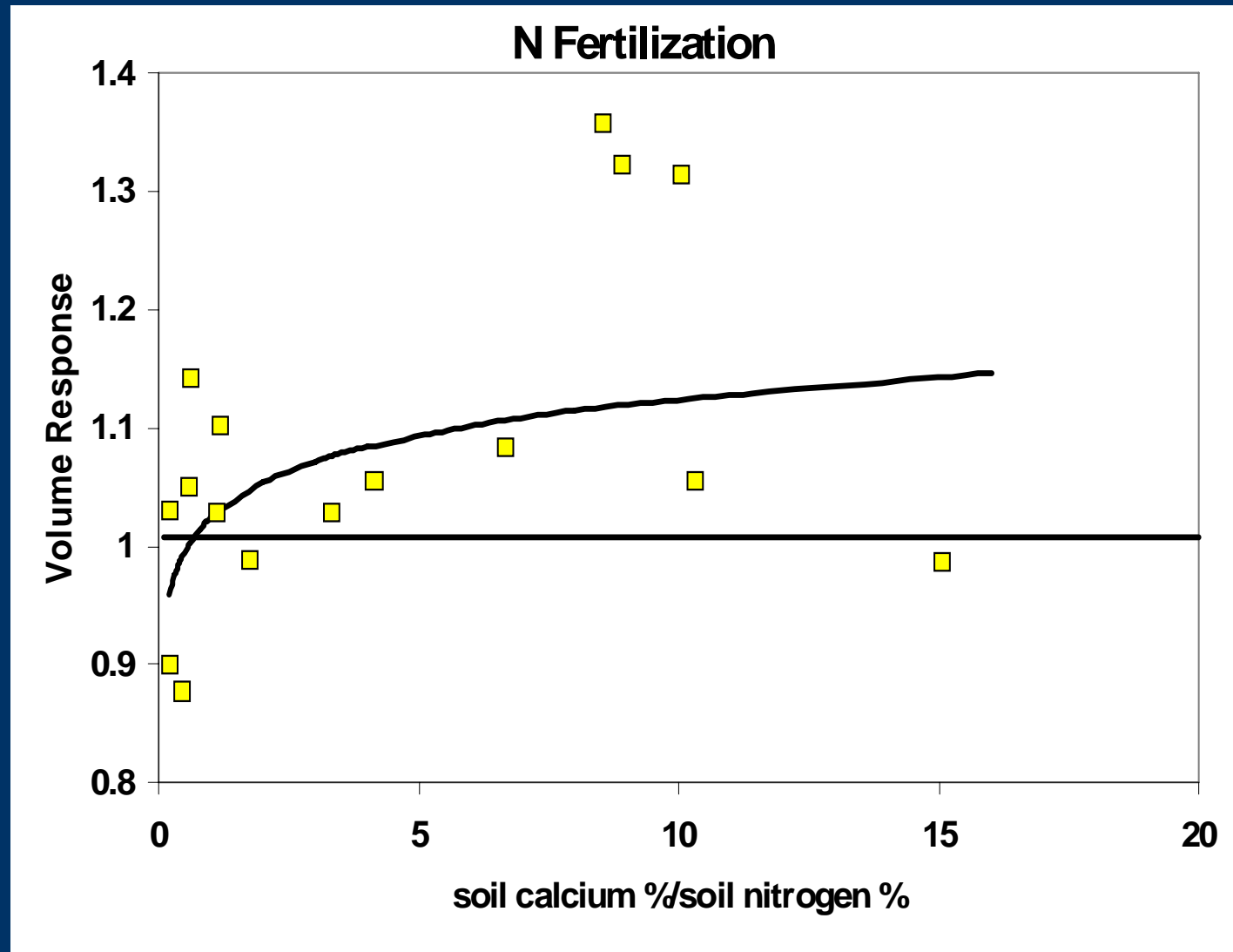
- Average foliage retention decreased at all but 2 sites (2.72 yrs to 2.39 yrs)
- Significant treatment decreases were associated with N, CaCl_2 and Kinsey treatments.
- When limited to the sites with the lowest foliage retention (initial FR <2.7 yrs), results generally the same except for a slight, though insignificant increase with lime treatment
- These results don't account for differences in total tree leaf area

Volume response

- On the regional level, volume production was greater following application of nitrogen, lime, and phosphorus
- After adjusting for covariates (dbh, ht, crown ratio, and plot-level basal area), increases in volume production were marginally greater with nitrogen and lime only (~3.4% increase)
- Significant positive volume responses varied by site
 - Urea.....2
 - Lime.....0
 - CaCl₂.....1
 - Phosphorus....2
 - Kinsey.....0
 - Fenn.....0
- Tested for correlation between treatment response and site-specific factors (soil and foliar chemistry)

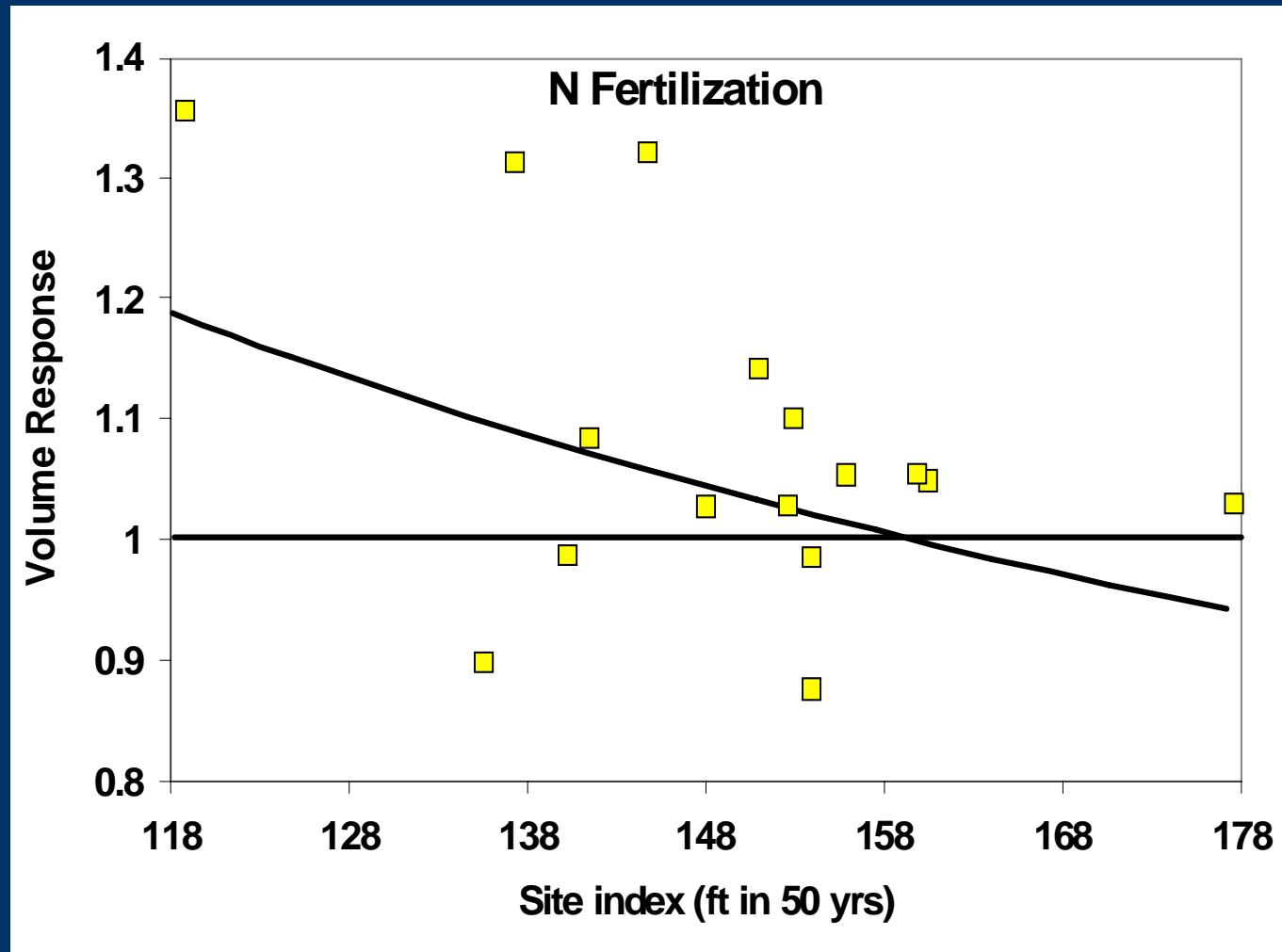
3-yr Volume Growth, N treatment

- Response to urea depended on soil Ca/N ratio
- Ca/N ratio generally increases with distance from coast

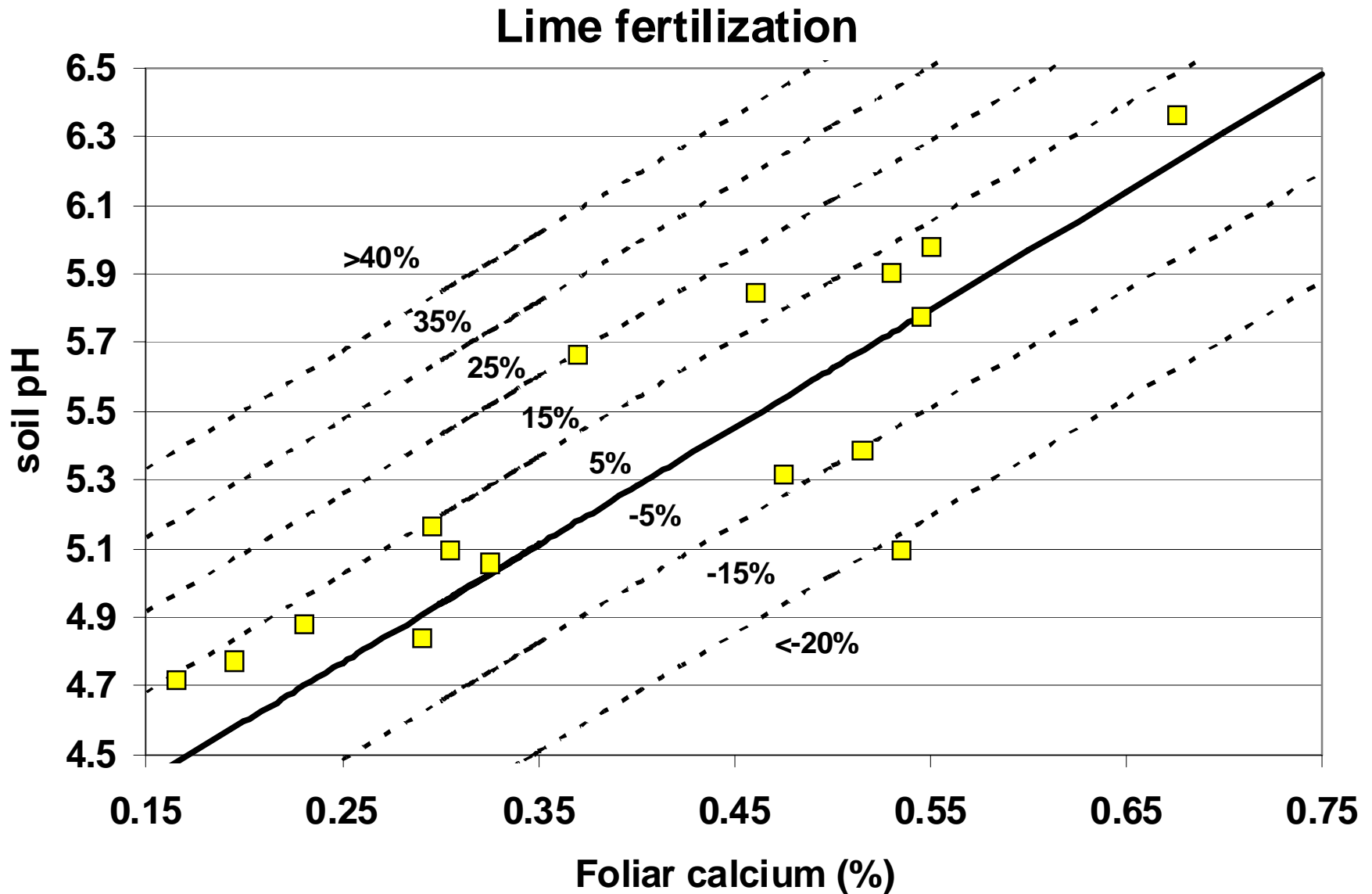


3-yr Volume Growth, N treatment

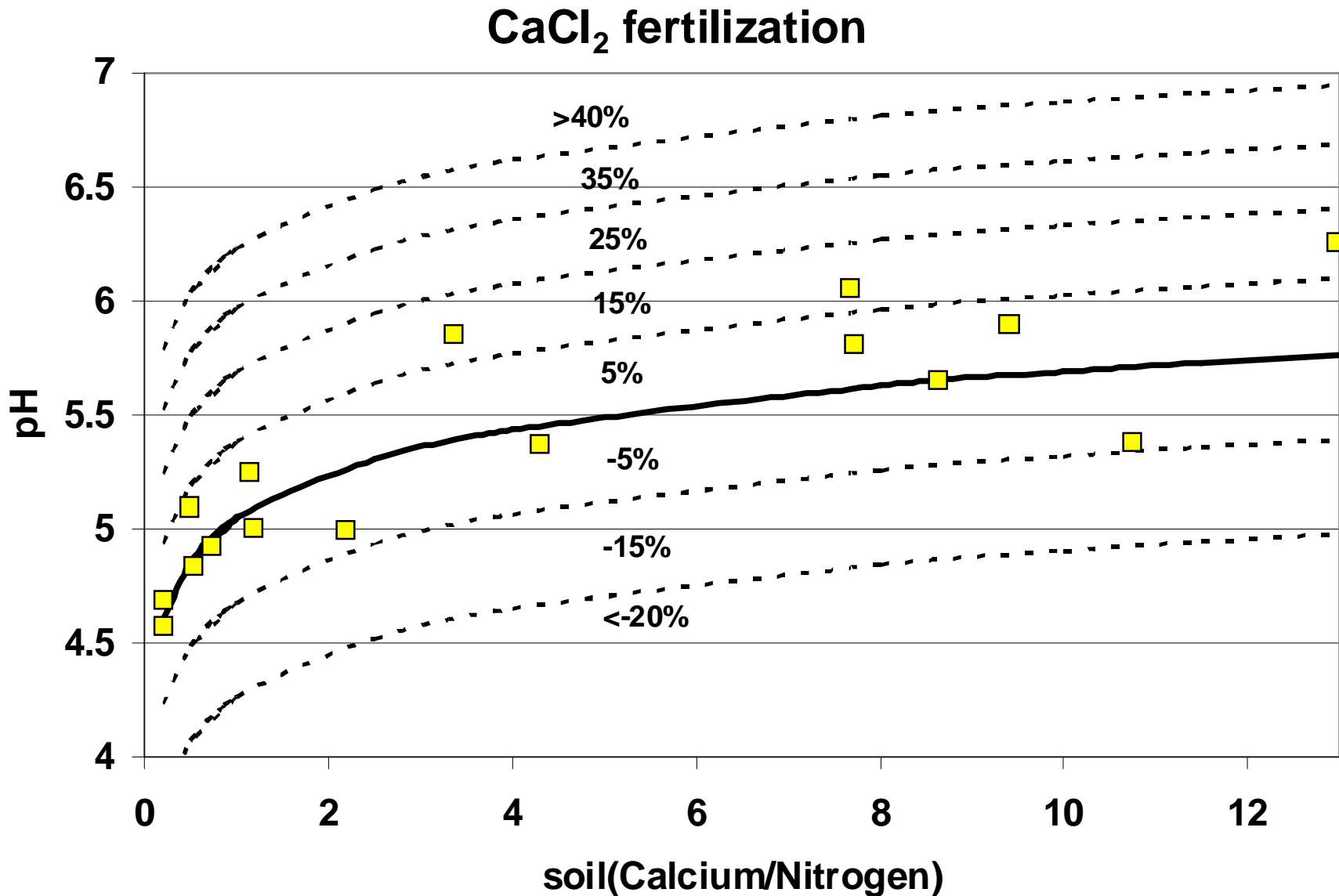
- Response to urea increases with decreasing site index



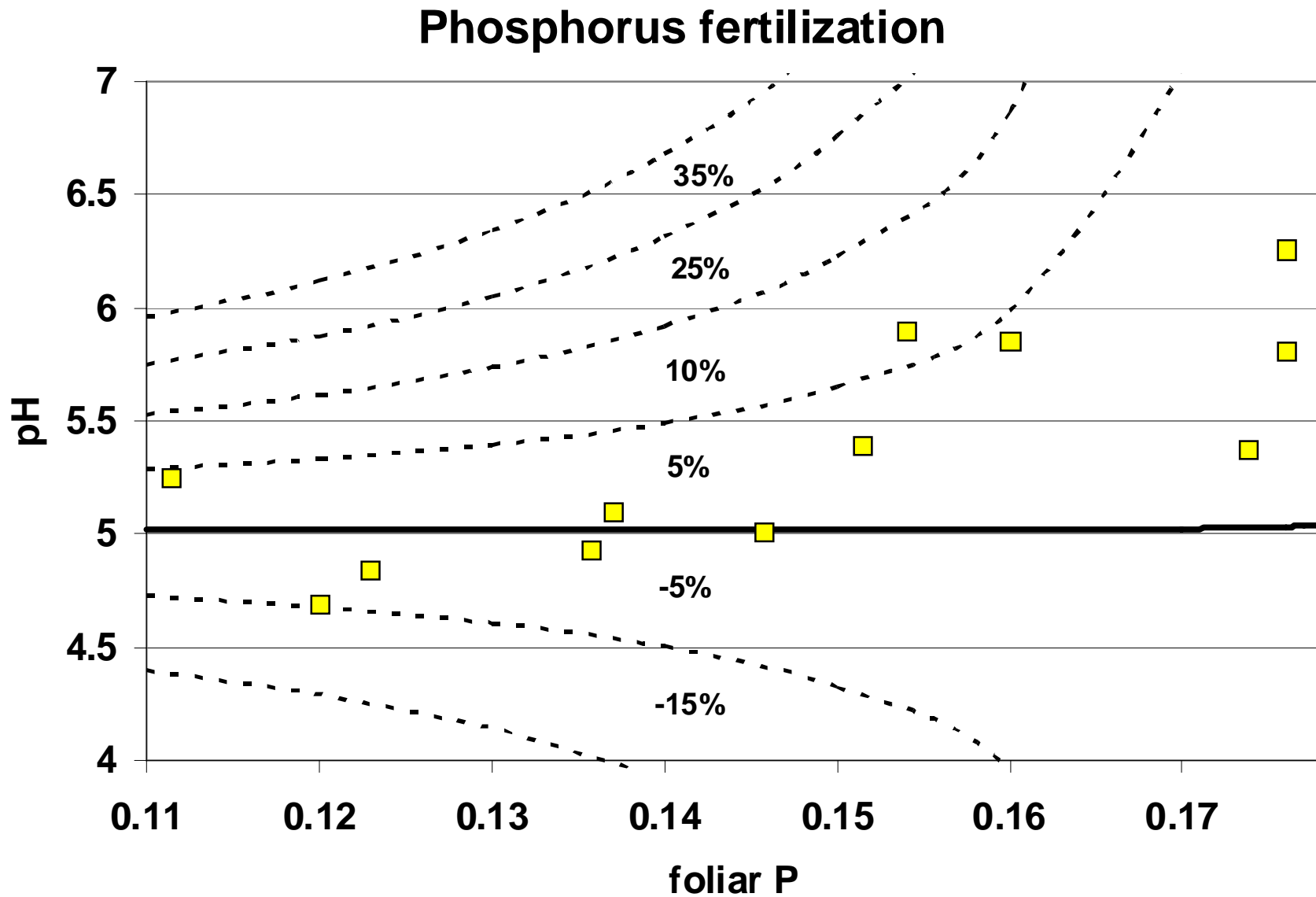
3-yr Volume Growth, Lime treatment



3-yr Volume Growth, CaCl₂ treatment

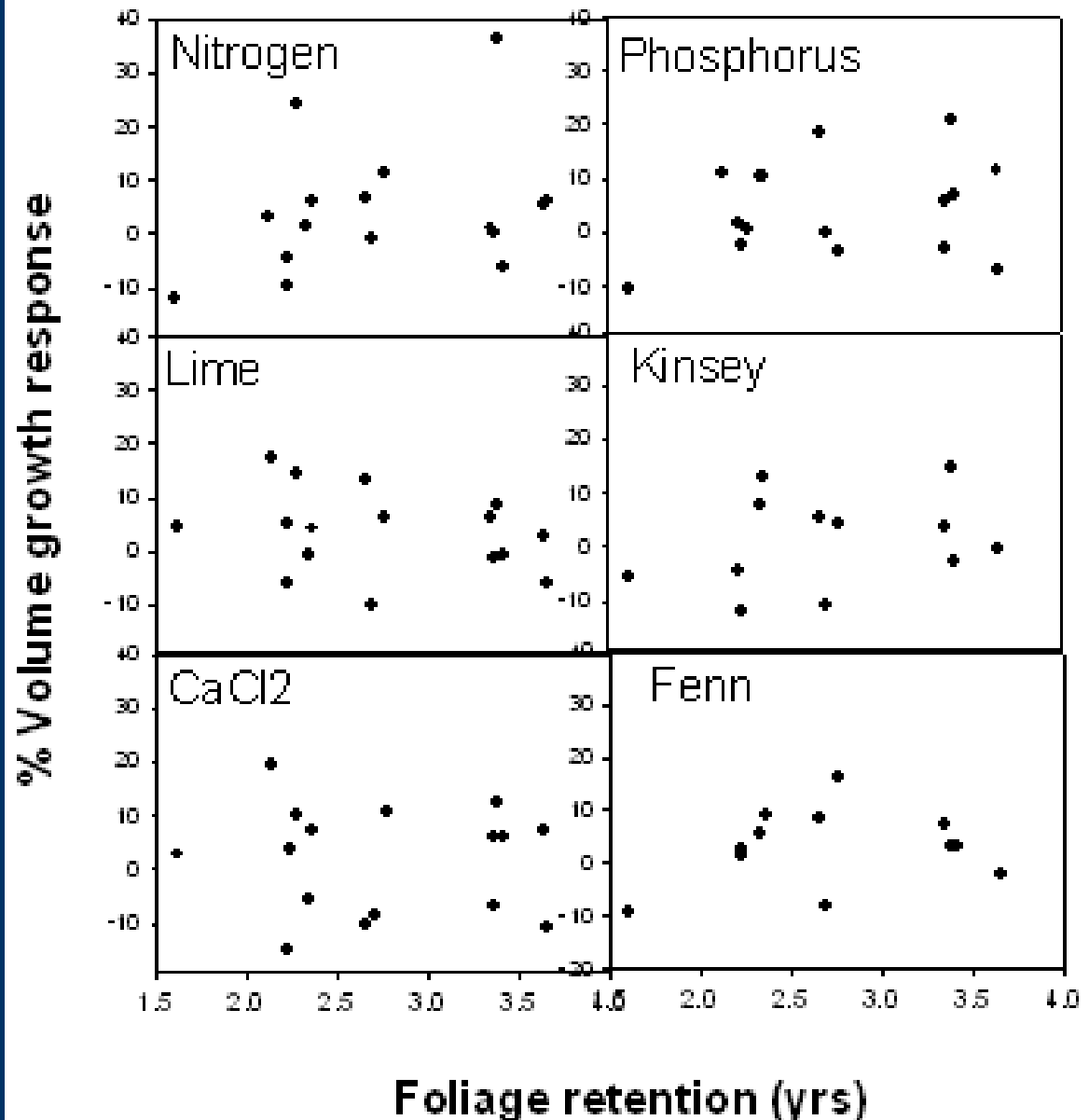


3-yr Volume Growth, Phosphorus treatment



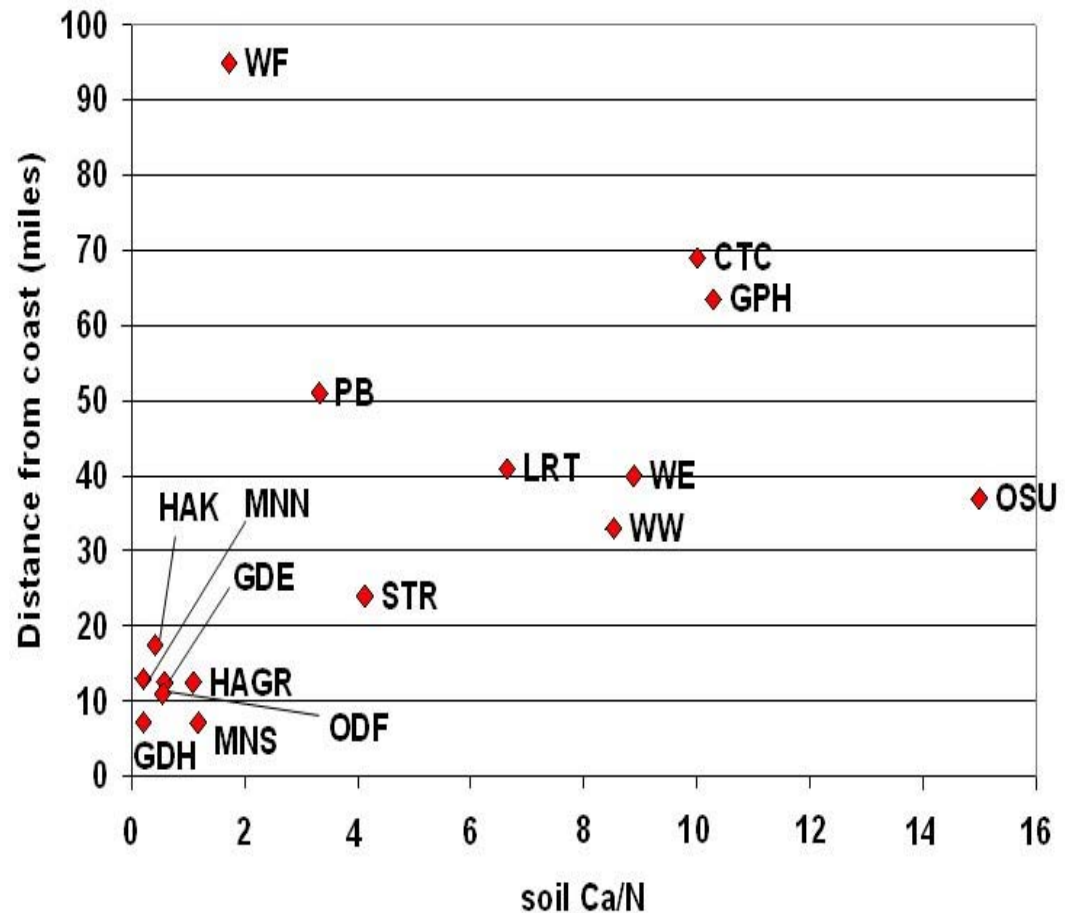
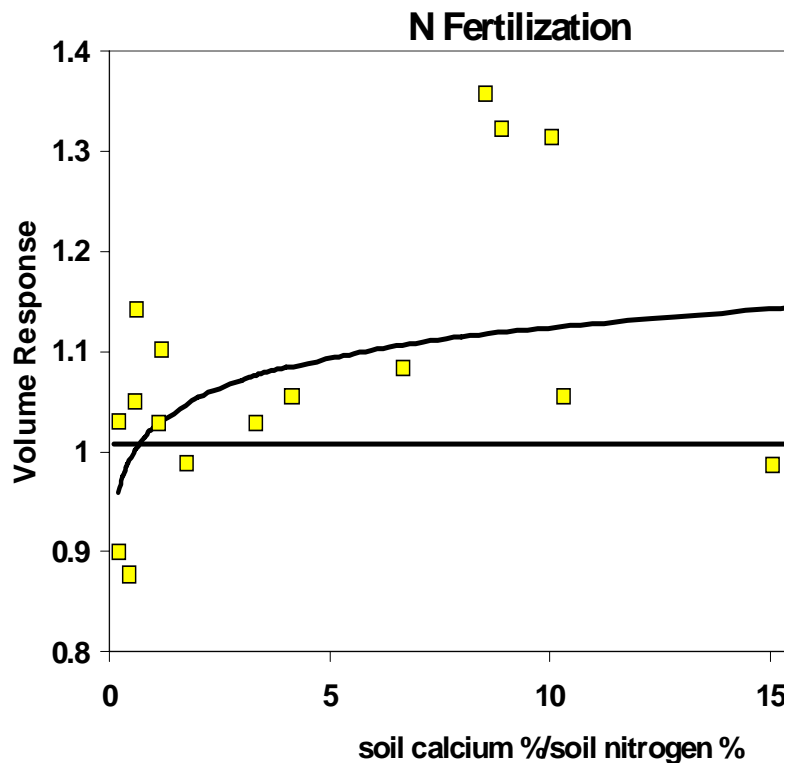
3-yr Volume Growth and SNC

- Foliage retention was generally not a significant predictor of volume growth



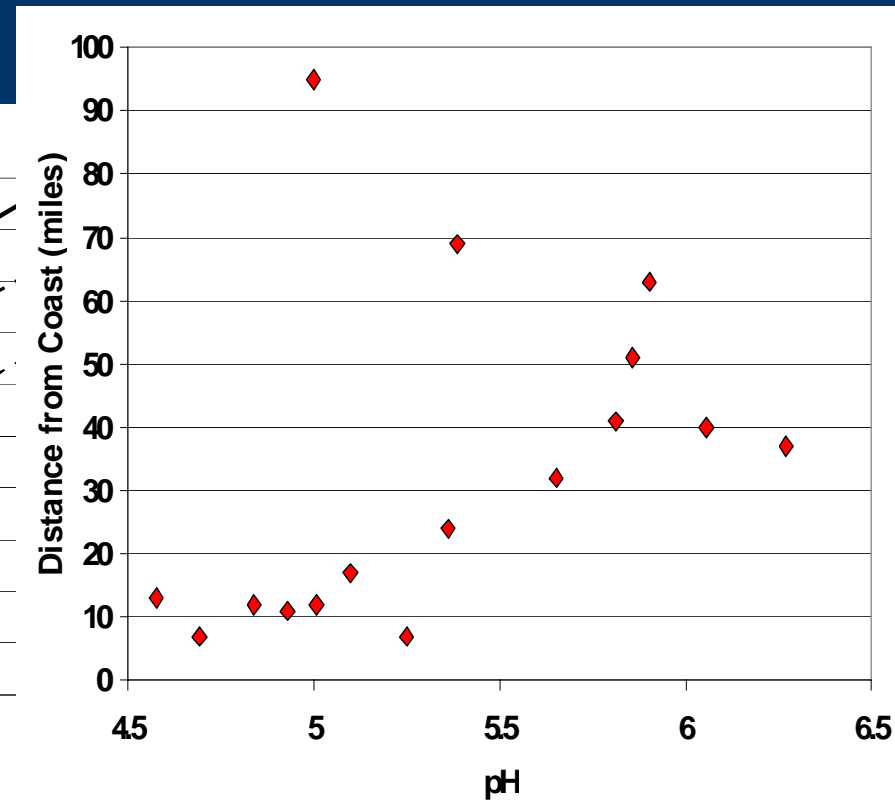
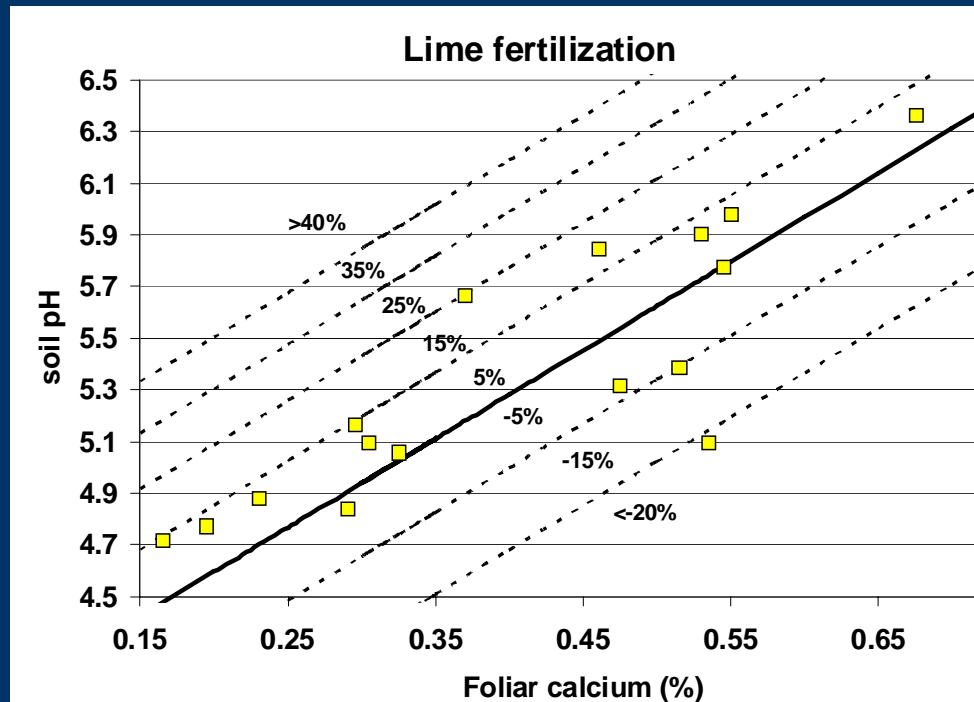
3-yr Volume Growth and SNC

- No response to N at low soil Ca/N ratios



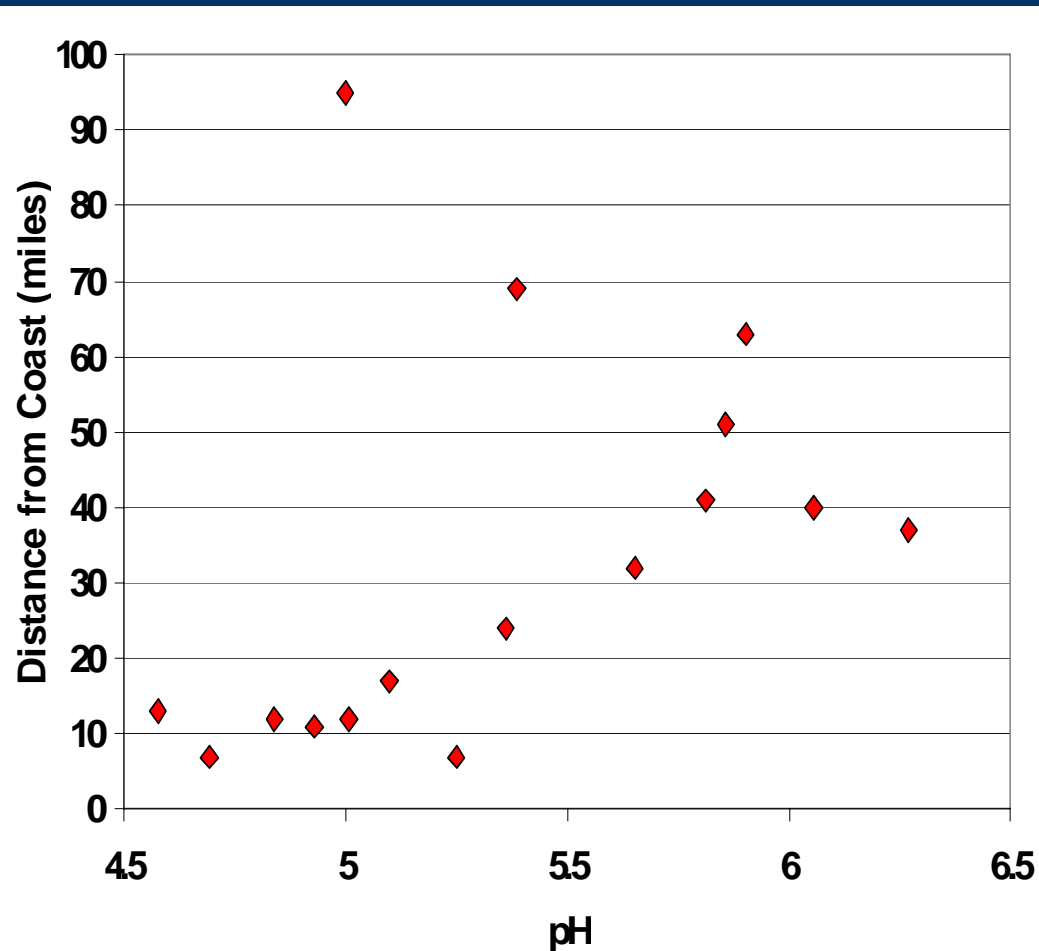
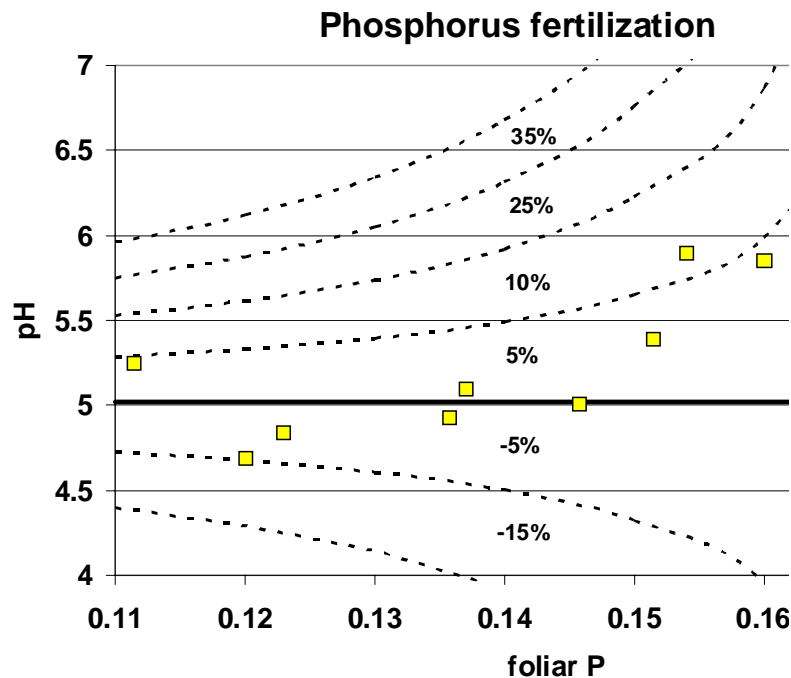
3-yr Volume Growth and SNC

- Response to lime at low pH possible if foliar calcium very low



3-yr Volume Growth and SNC

- No response to Phosphorus at pH < 5

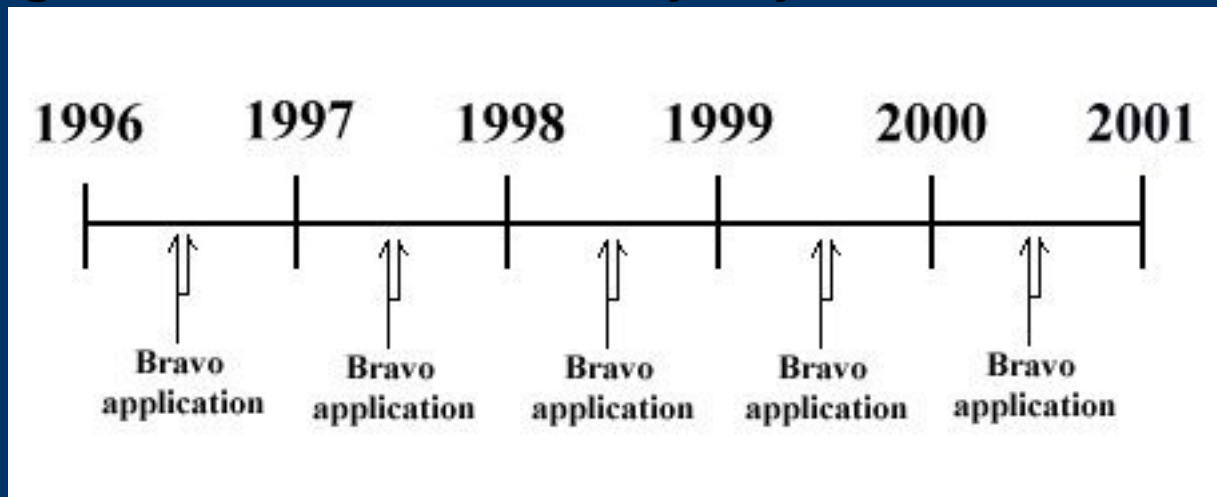


Fungicidal trials

- Fungicidal treatment of Swiss needle cast is common in Douglas-fir Christmas tree plantations
- Appropriate period for treatment is in the spring during shoot elongation
- Numerous products have been tested: most effective is BRAVO; most acceptable is sulfur

BRAVO fungicide, methods

- Five-acre paired control and treatment plots installed in 1996 (3 blocks)
 - Interior 0.5 acre was measured for growth, foliage retention
- Treatment plot received aerial application of BRAVO twice per year for five consecutive years in spring (1996-2000)
- Tree growth measured annually in years 0-5



BRAVO fungicide

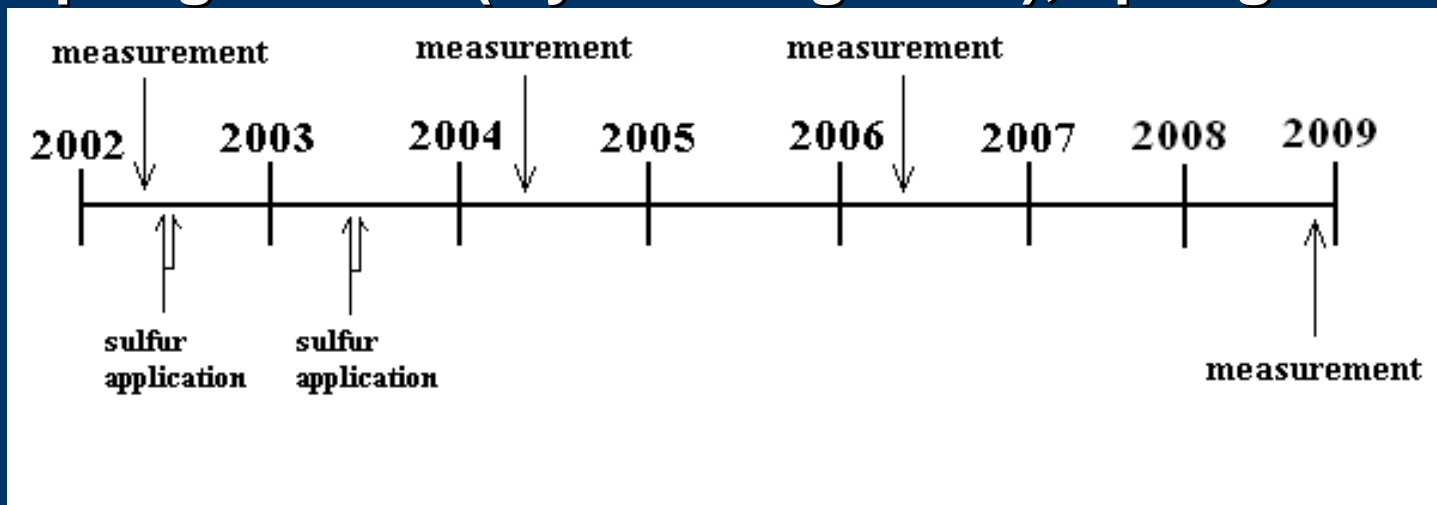
- **Foliage retention**
 - Foliage retention increased with treatment; increase with treatment averaged 0.88 years over 3 blocks, ranging from 0.71 to 1.05 years.
 - Fungicide application increased average foliage retention from 1.94 to 2.82 years.
- **Crown sparseness**
 - Crown sparseness (crown length/crown base sapwood area) was significantly reduced with treatment after site was accounted for

BRAVO fungicide, tree growth

- **After 5 years, volume growth of treated stands averaged 35% greater than control stands ($R^2= 0.87$).**
- **In final 3 years, treated stands averaged 60% greater growth than control stands ($R^2= 0.80$).**

Sulfur fungicide, methods

- Five-acre paired control and treatment plots (5 sites)
 - Interior 0.5 acre was measured for growth
- Treatment plot received aerial application of micronized sulfur twice per year in each of June of 2002, June of 2003
- Measure plots measured prior to treatment, spring of 2004 (2 years of growth), spring of 2006



Sulfur fungicide, tree growth

- Volume growth

- Period 1: No difference in growth between treated and untreated trees
- Period 2: Treated trees grew marginally greater volume (~10%) in the second two year period
- Period 3: Treated trees grew marginally greater volume (~10%) in the third period

- Sidenote

- Trees were treated in 2002 and 2003, during which time spring was relatively dry and infection may have been light with or without fungicide