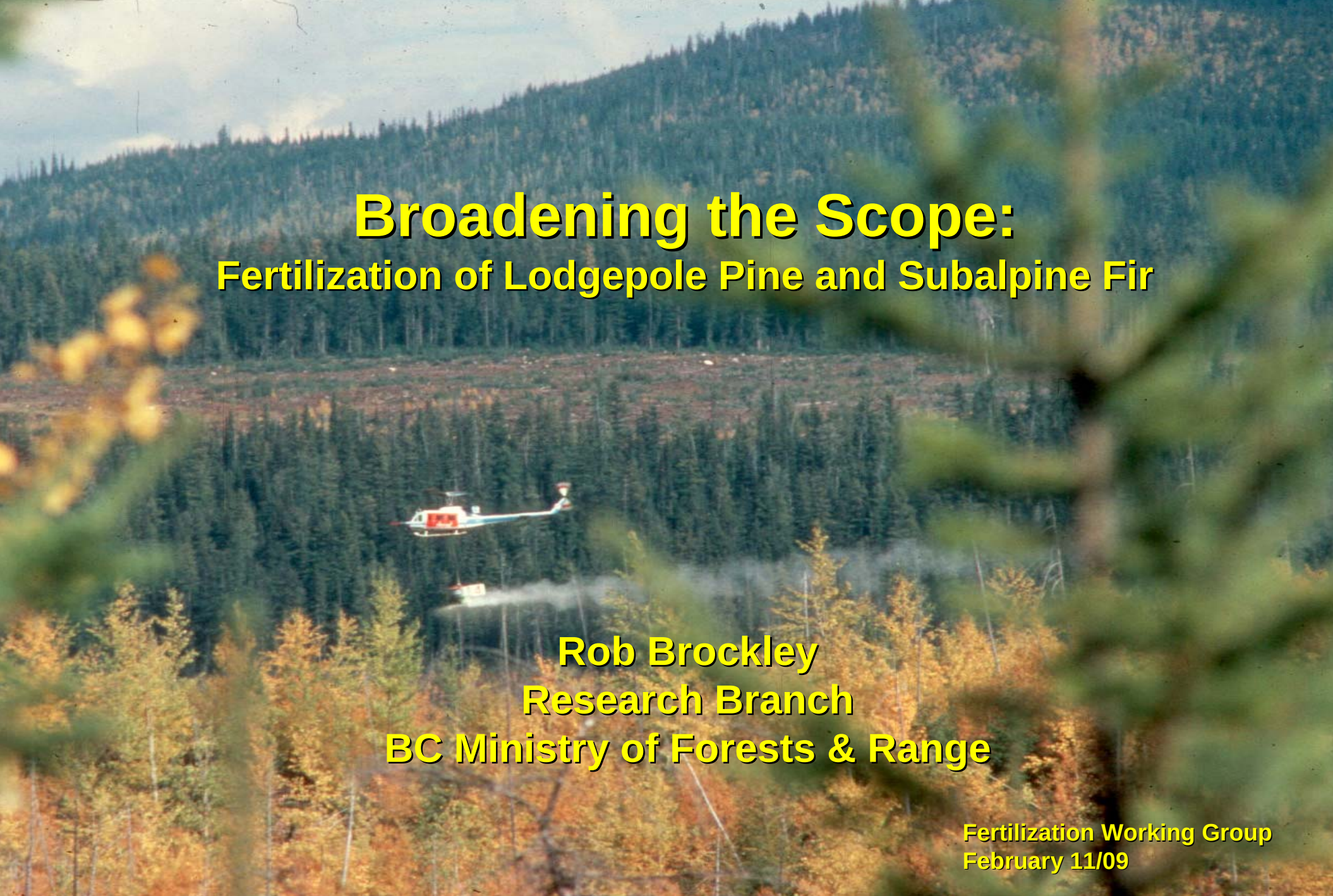

Broadening the Scope:
Fertilization of Lodgepole Pine and Subalpine Fir

Rob Brockley
Research Branch
BC Ministry of Forests & Range

Fertilization Working Group
February 11/09

Lodgepole pine

Susceptibility of fertilized lodgepole pine to MPB attack

- Fertilized lodgepole pine is more susceptible to attack, especially under high MPB pressure

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  - Dilution of resin canal defences

Susceptibility of fertilized lodgepole pine to MPB attack

- Fertilized lodgepole pine is more susceptible to attack, especially under high MPB pressure
  - Larger dbh
  - Microclimate changes
  - Dilution of resin canal defences
  - Sensory cues due to nutrient imbalance

Lodgepole pine fertilization research

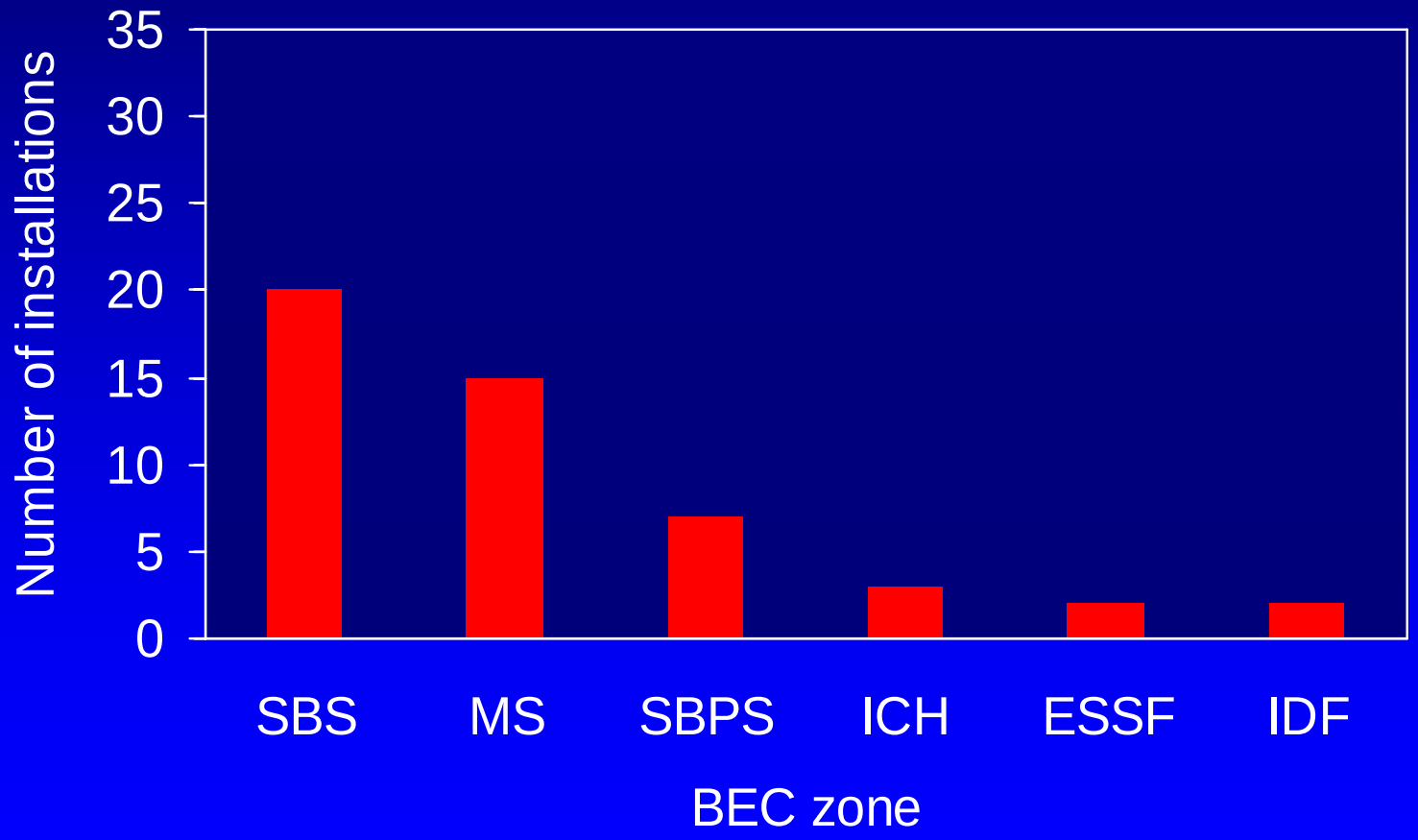
- ~ 70 screening trials

Lodgepole pine fertilization research

- ~ 70 screening trials
- 50 area-based trials

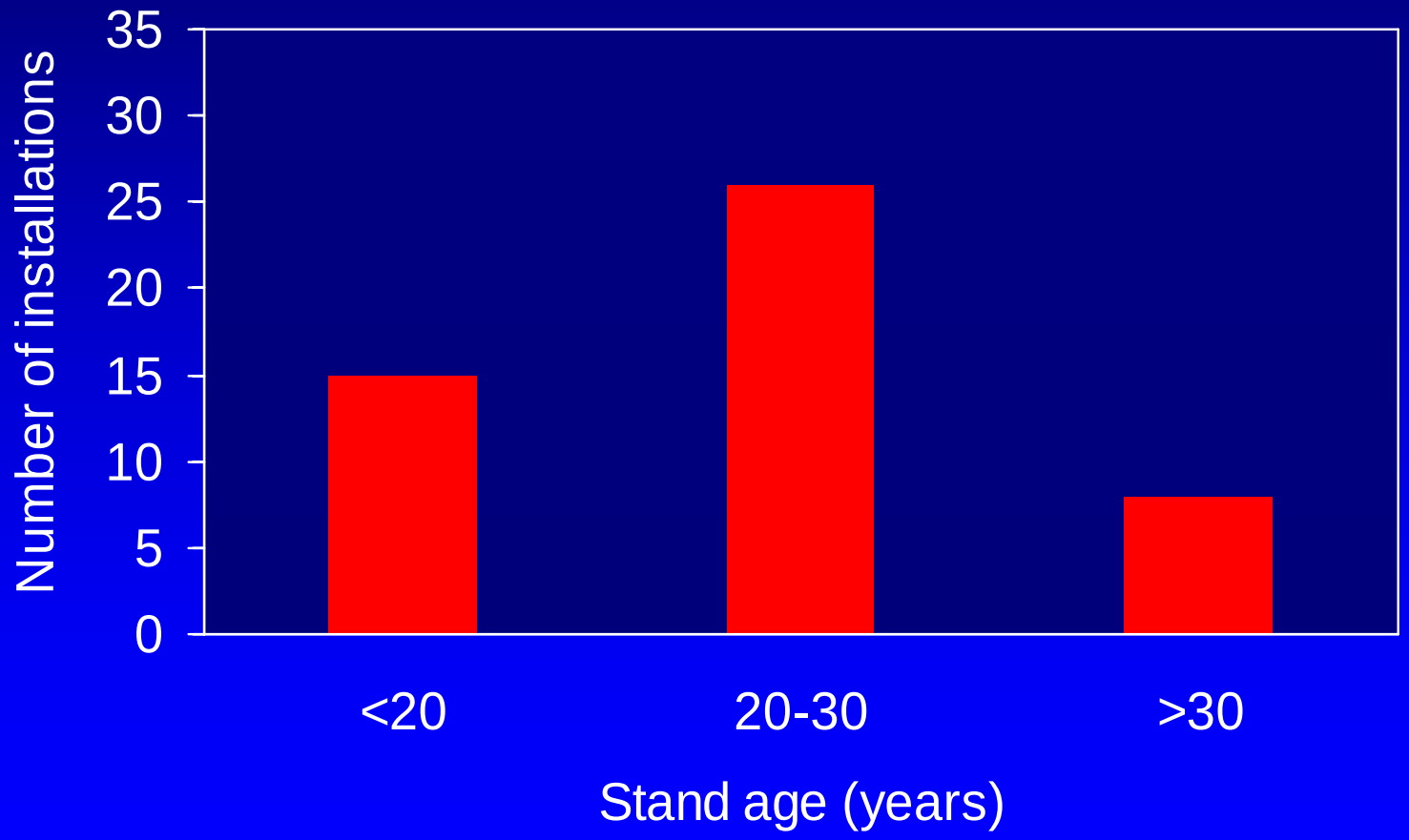
Lodgepole pine fertilizer research trials

Distribution by biogeoclimatic zone (n=49)



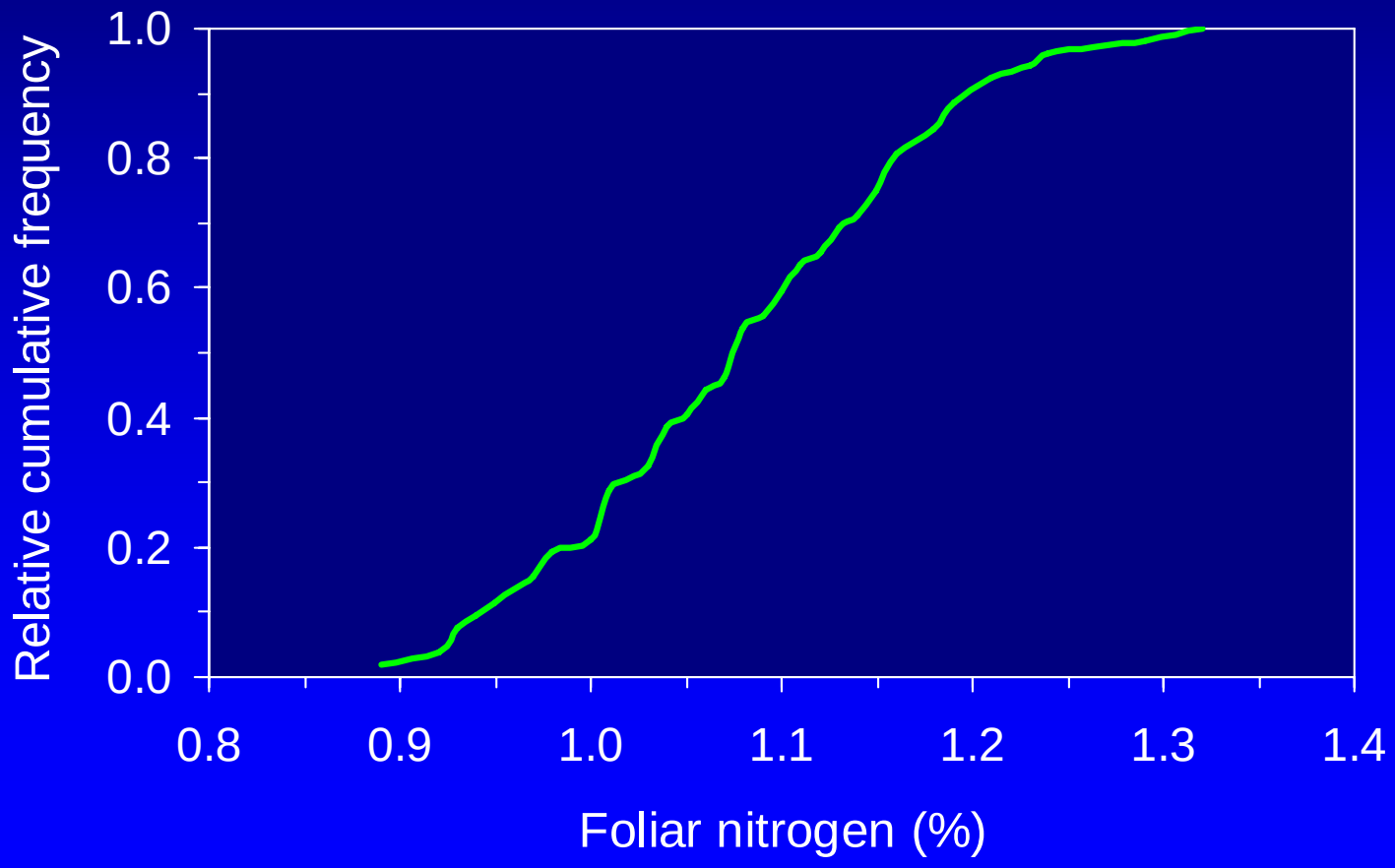
Lodgepole pine fertilizer research trials

Distribution by stand age (n=49)



Lodgepole pine foliar N concentration

Relative cumulative frequency distribution (n=58)



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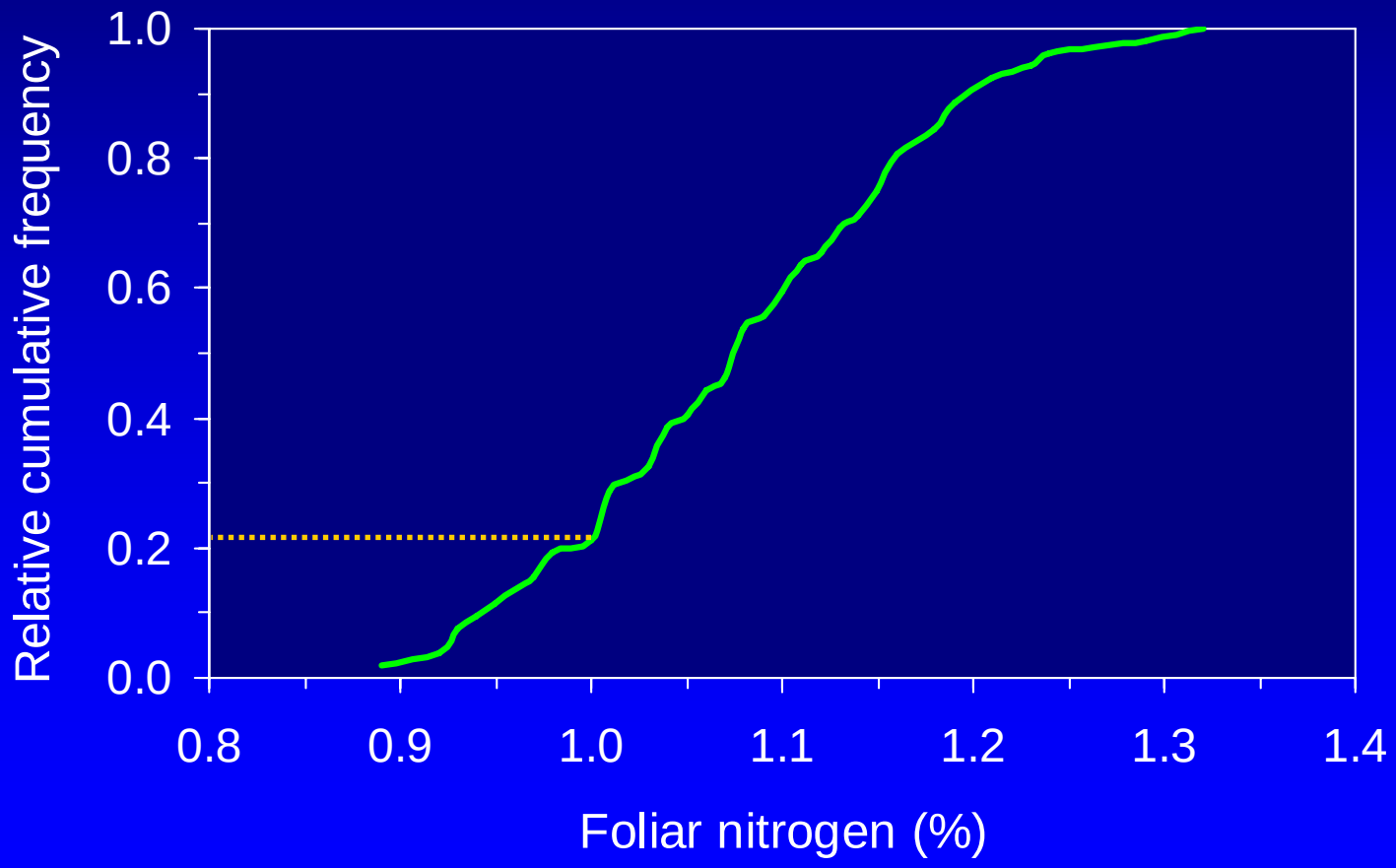

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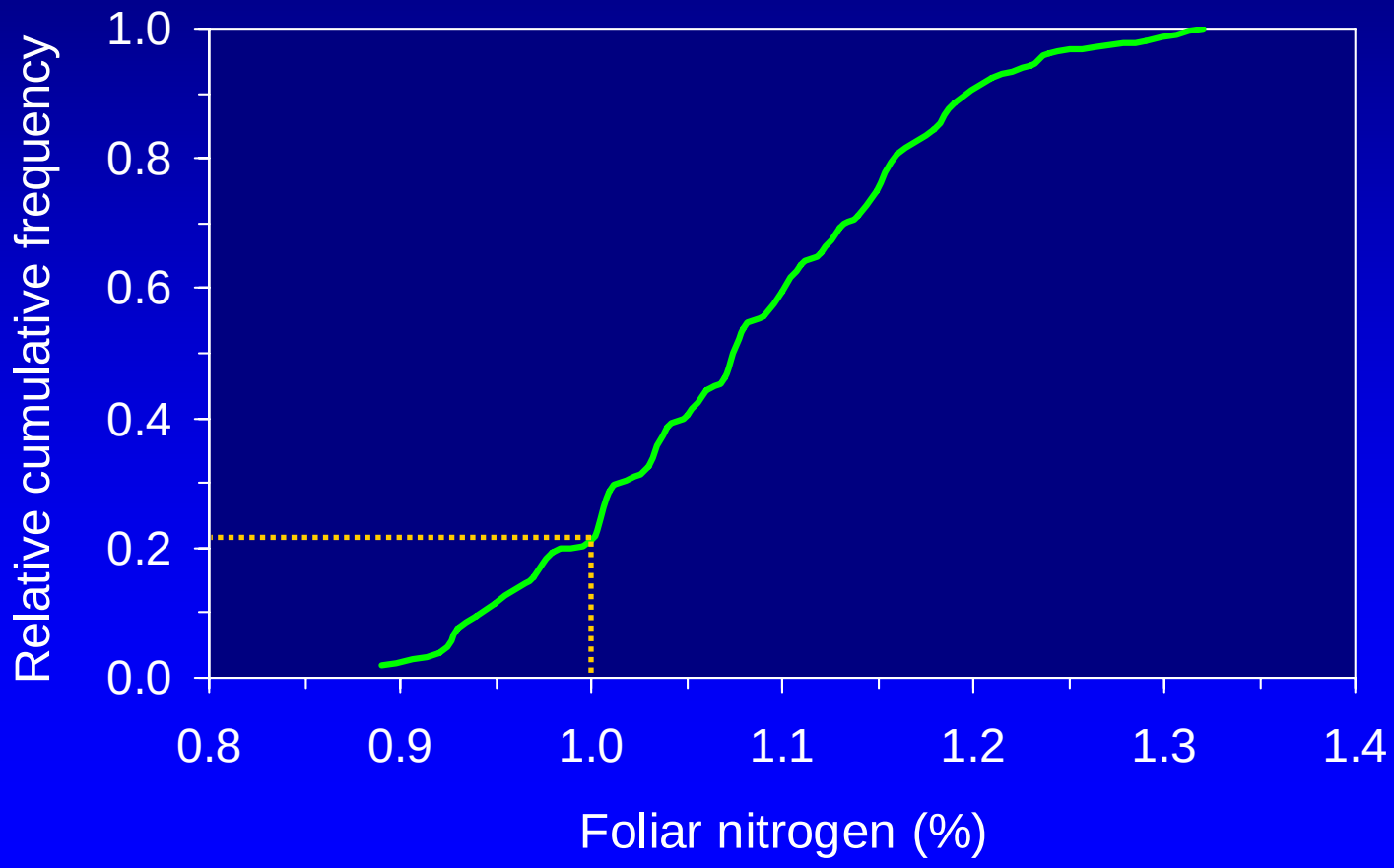

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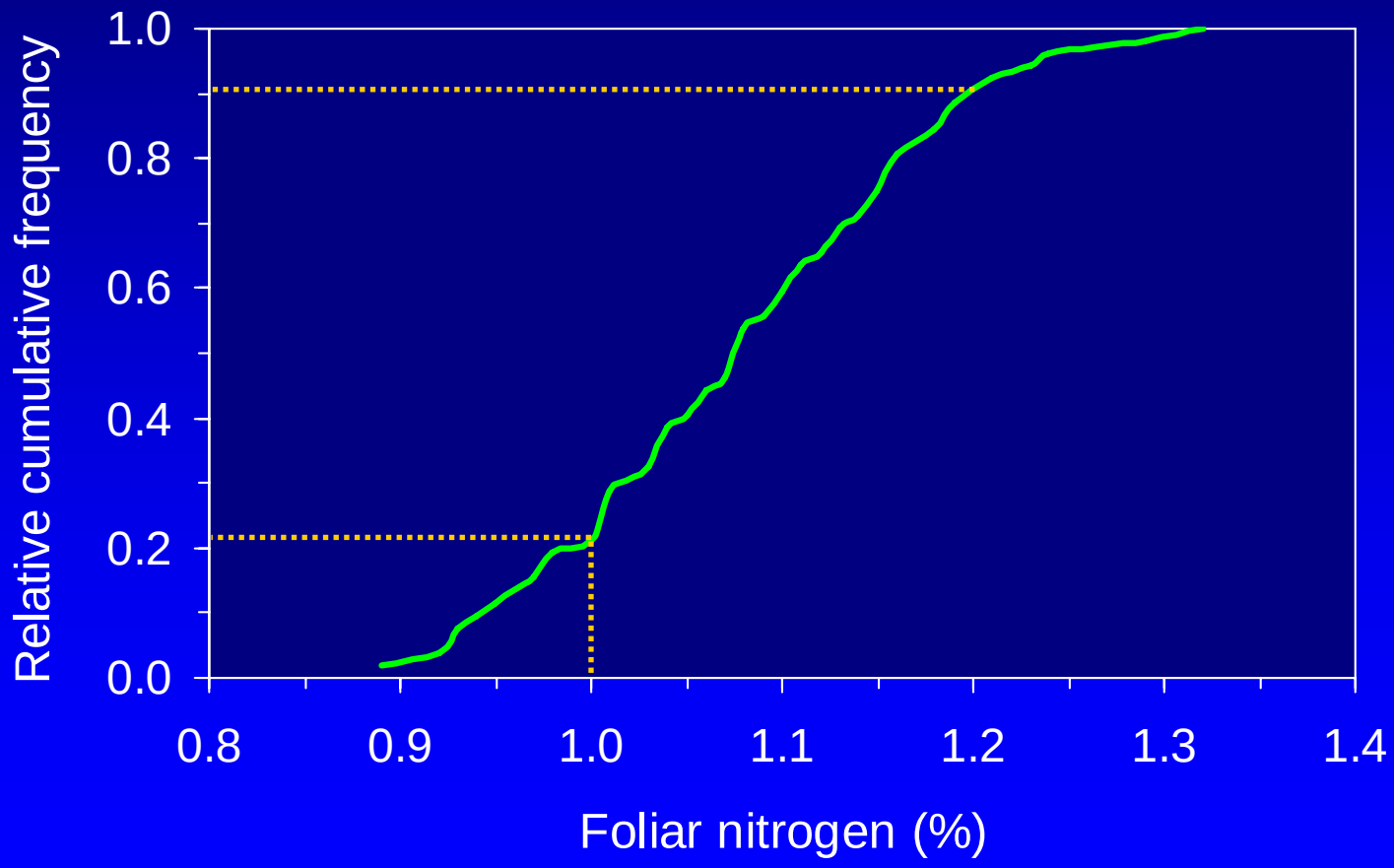

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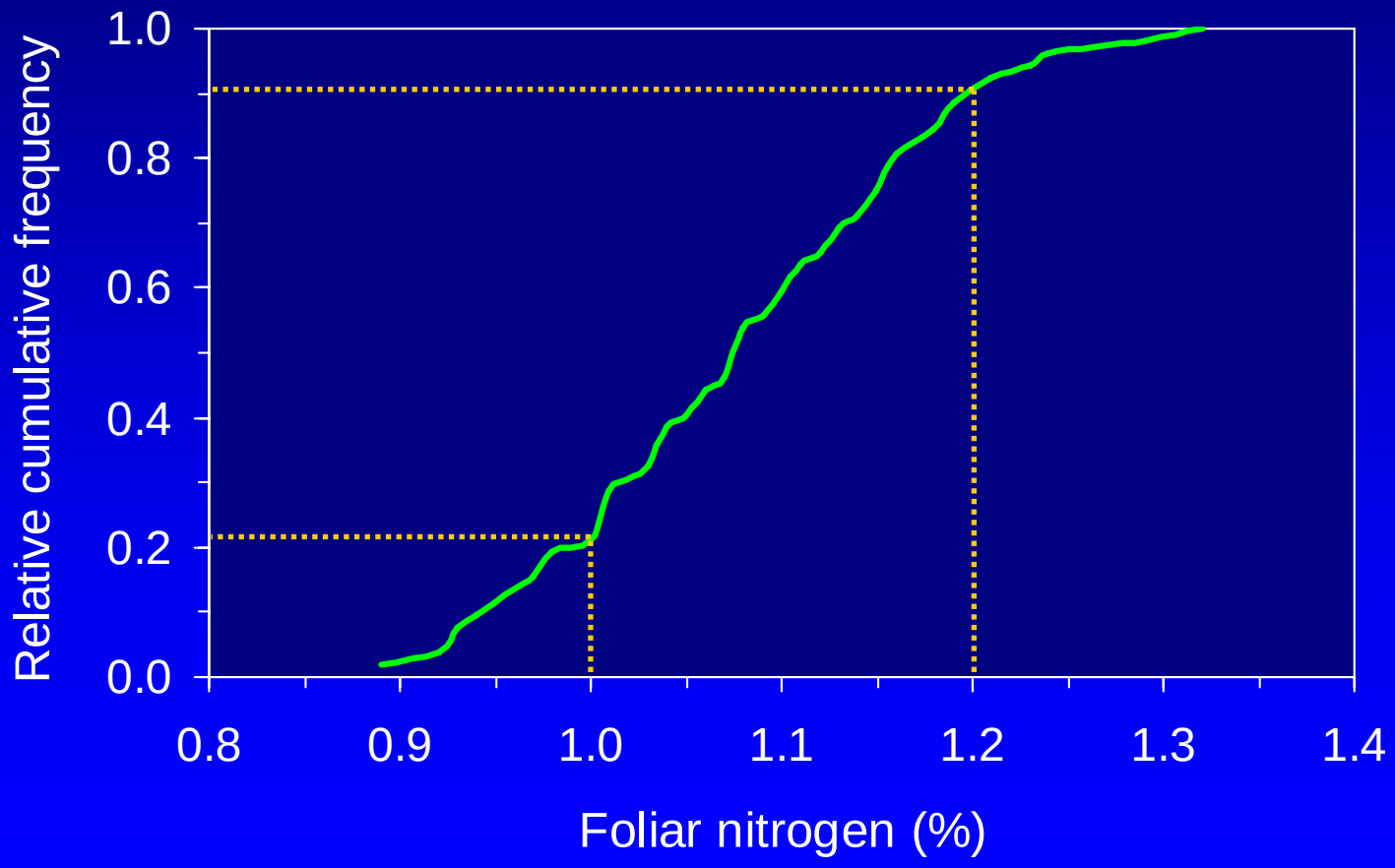
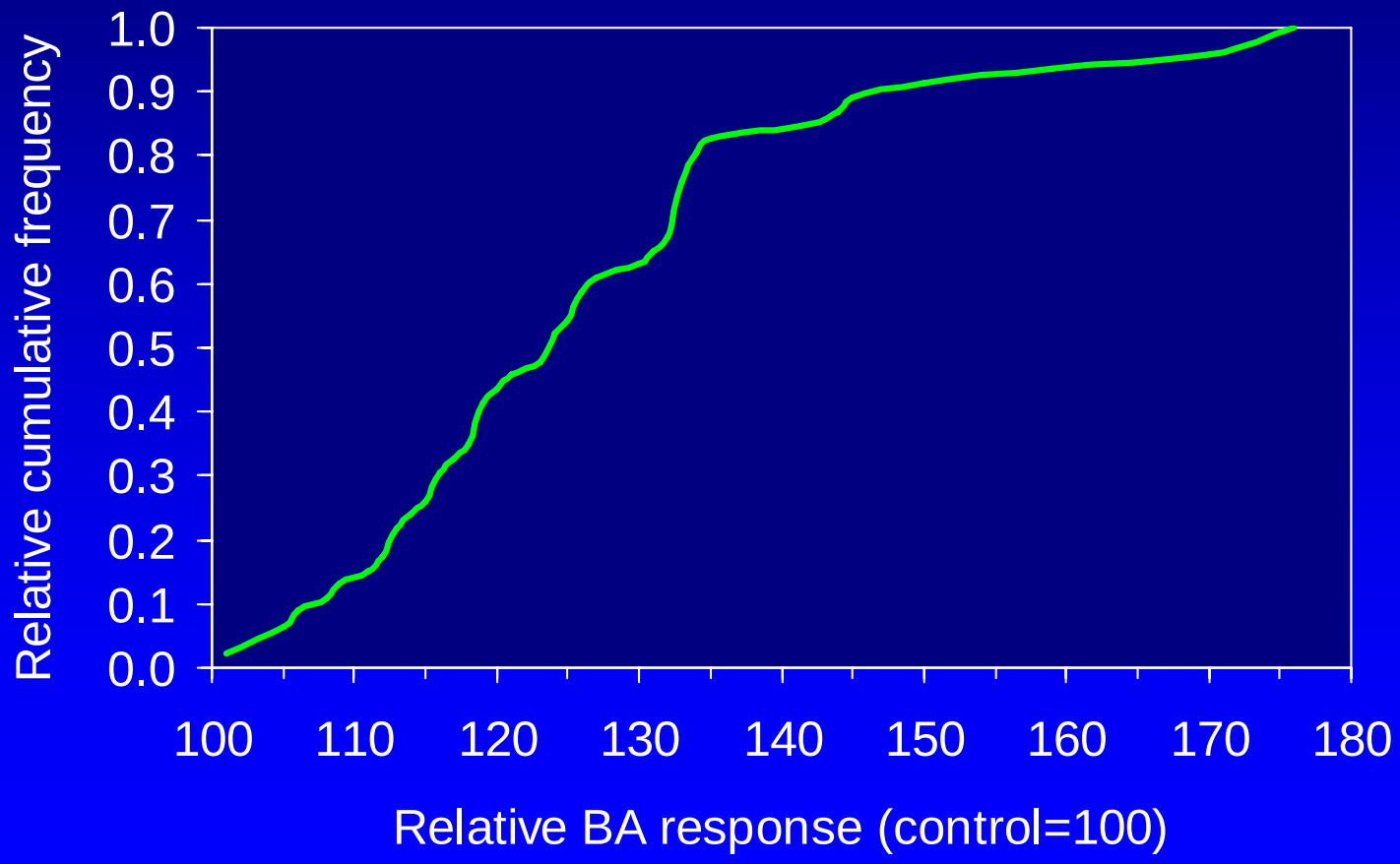


Relative 6-year BA response following N fertilization

Relative cumulative frequency distribution (n=46)



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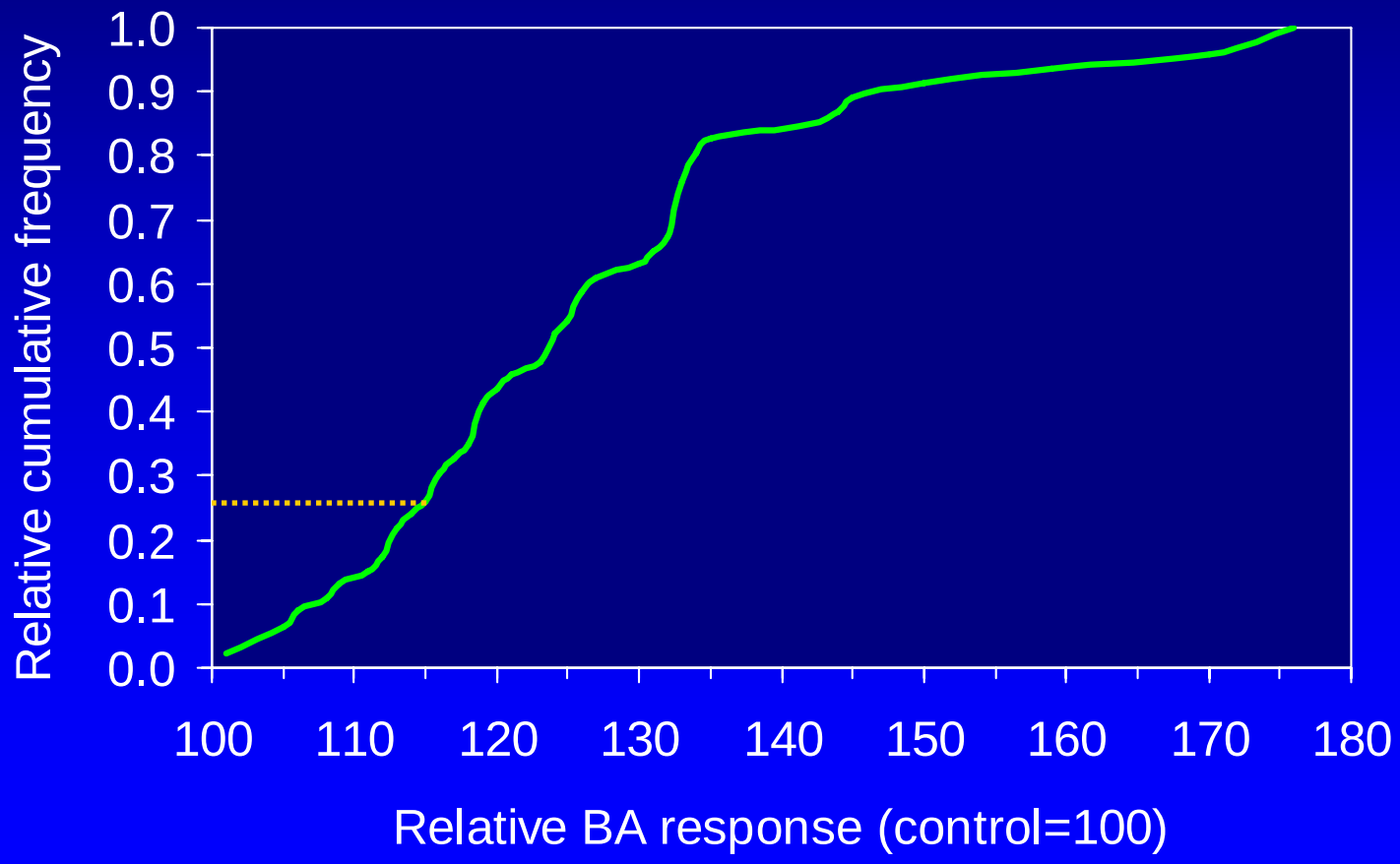

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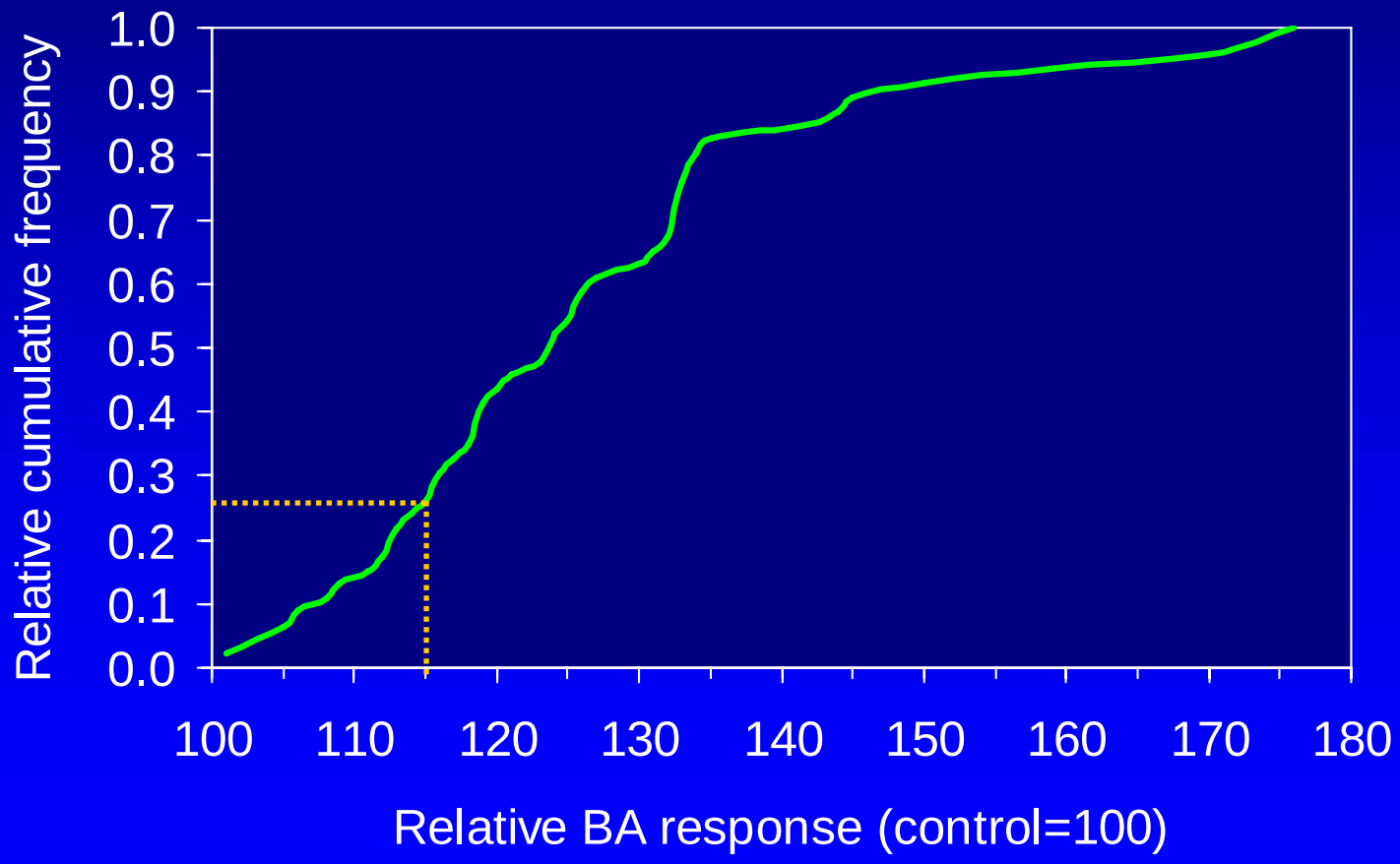

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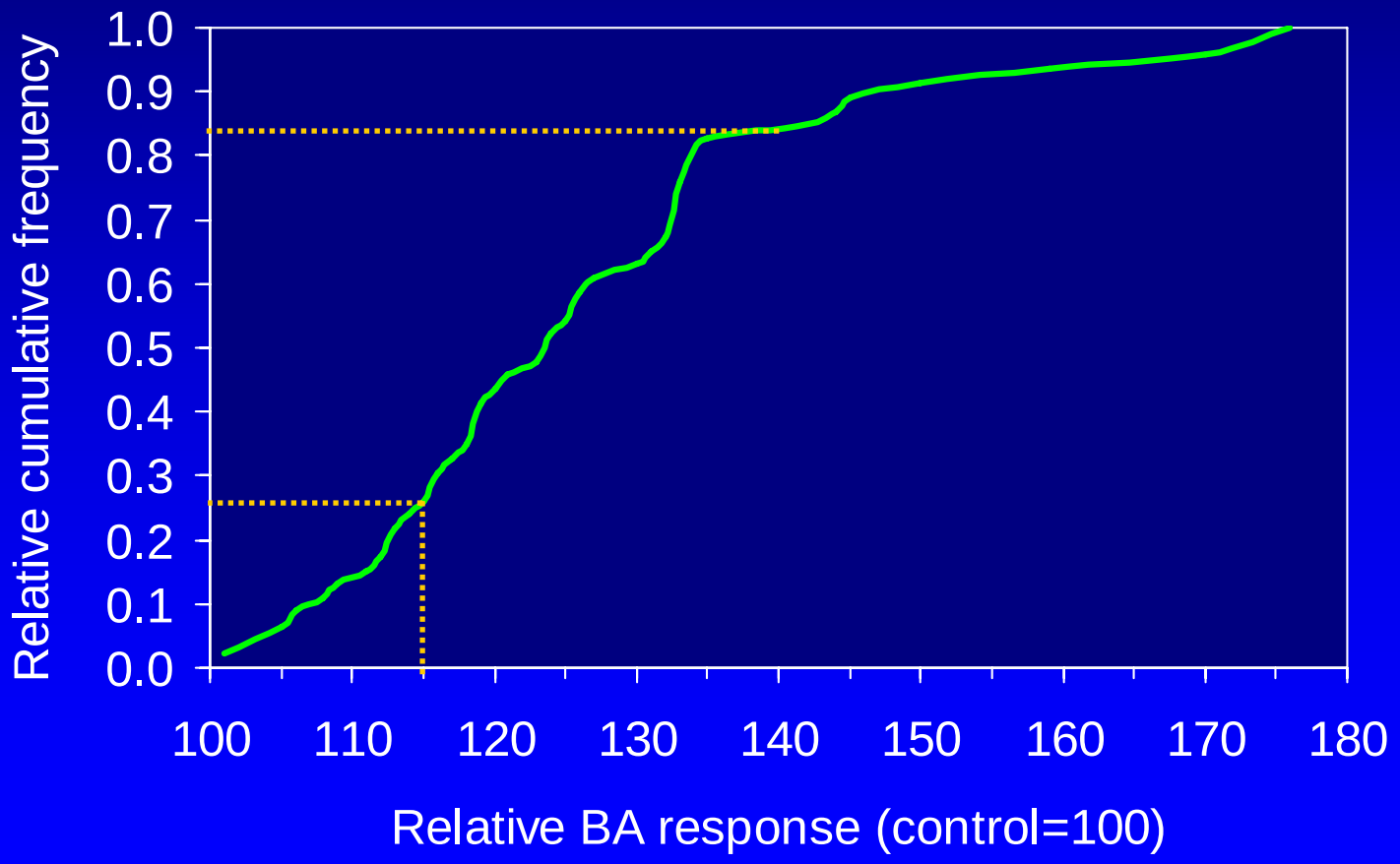

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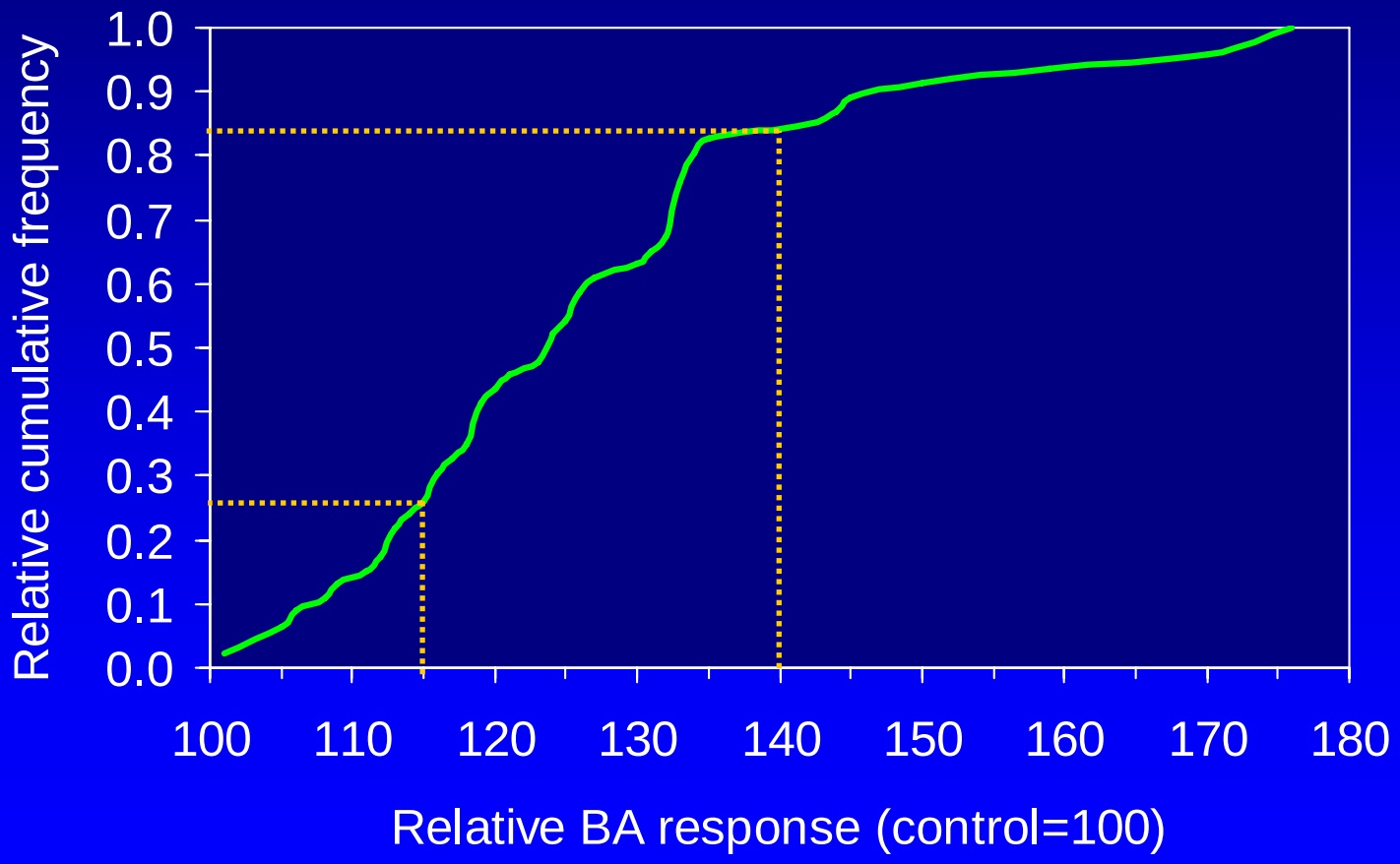
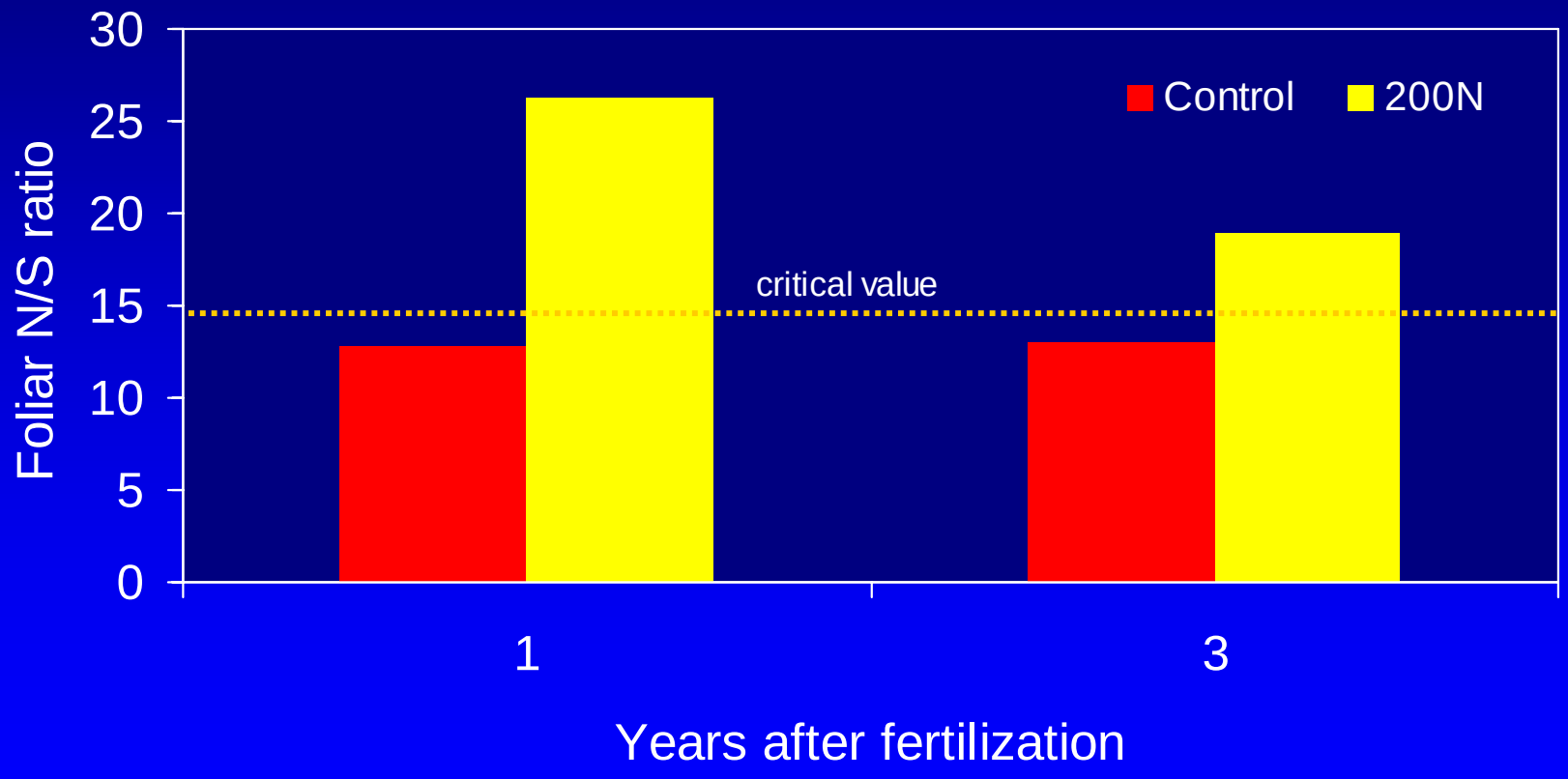


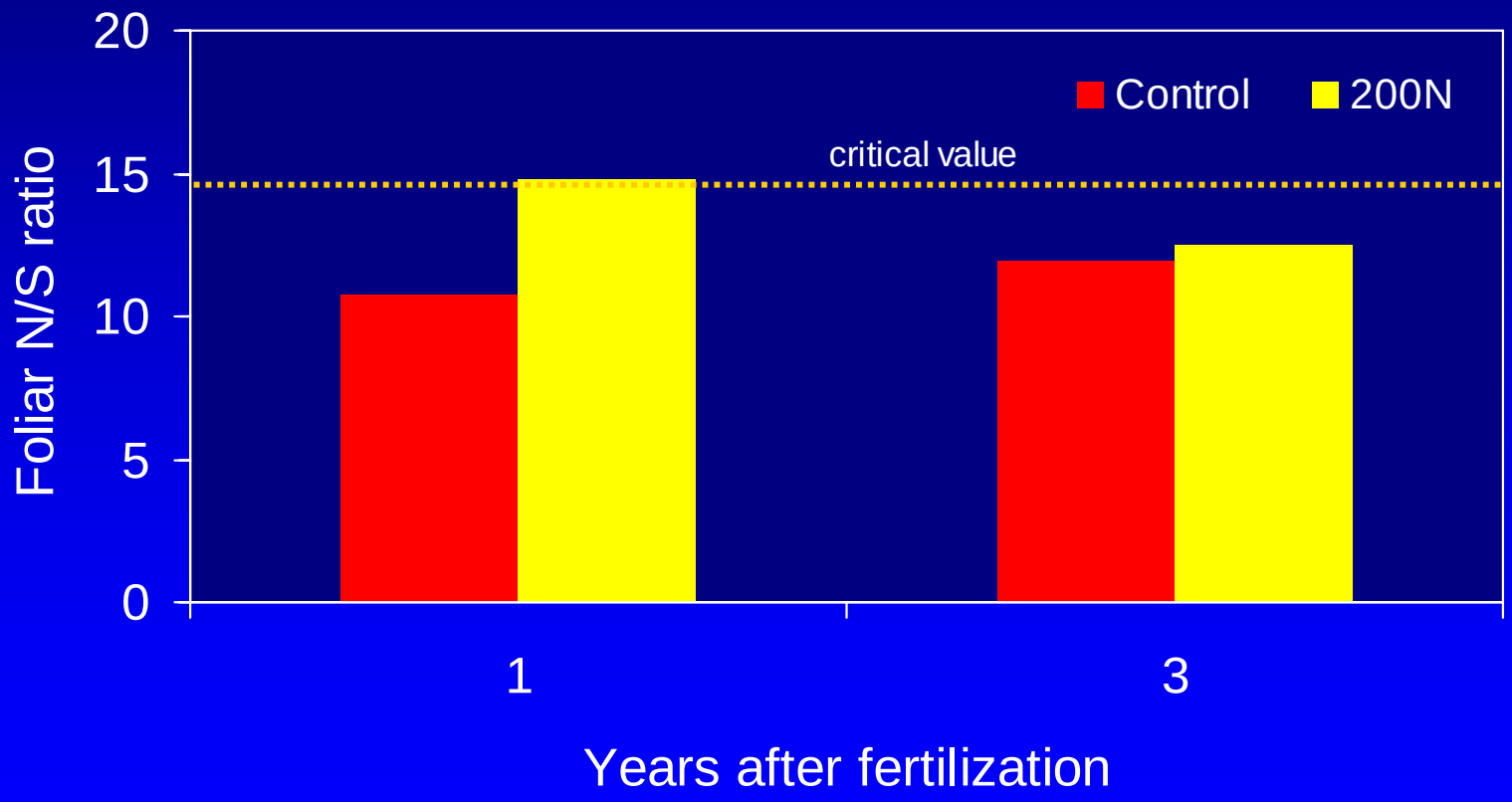
Foliar N/S ratio by treatment and year

EP 886.01 Inst. #17



Foliar N/S ratio by treatment and year

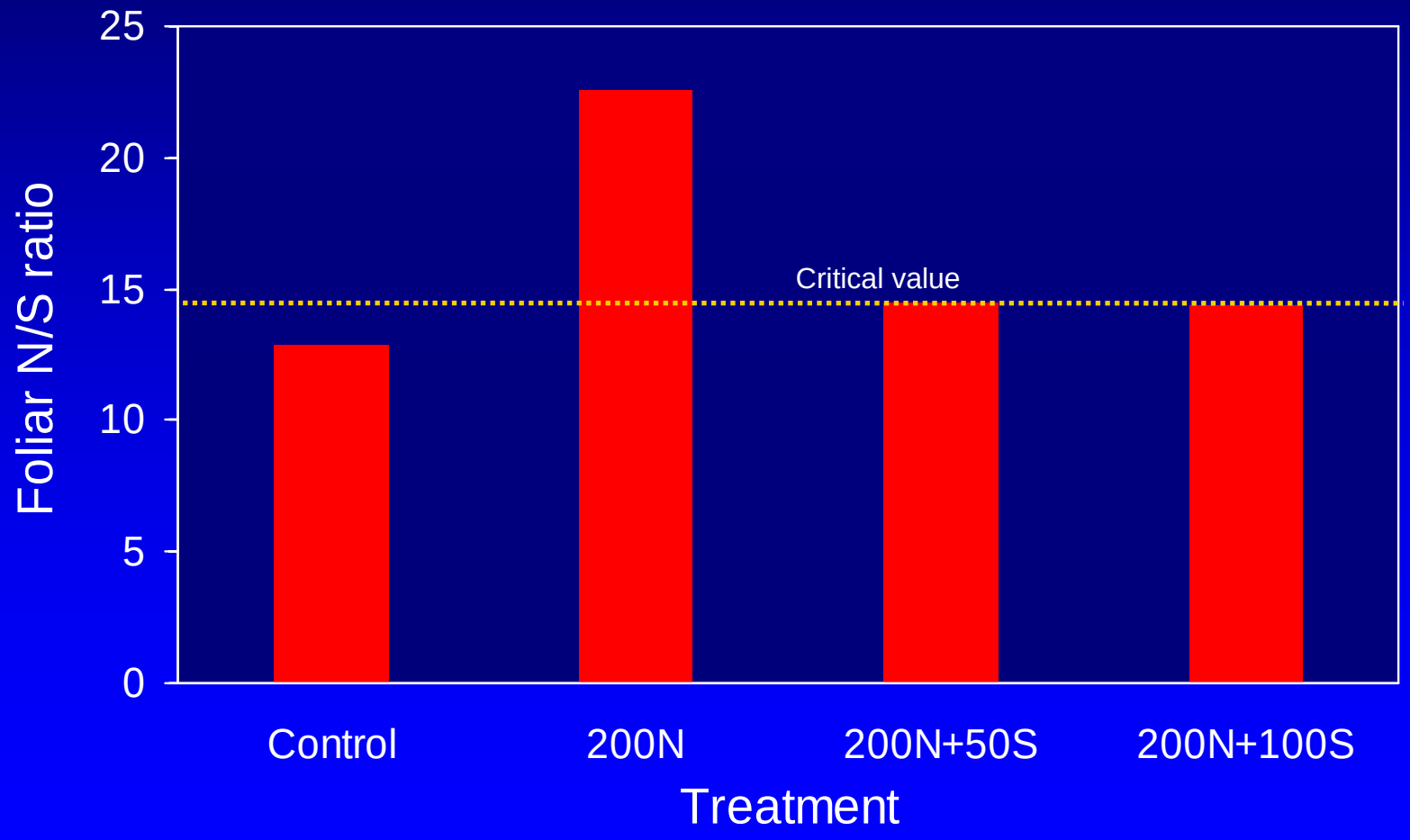
EP 886.01 Inst. #24



Control 200N 200N + 50S 200N + 100S

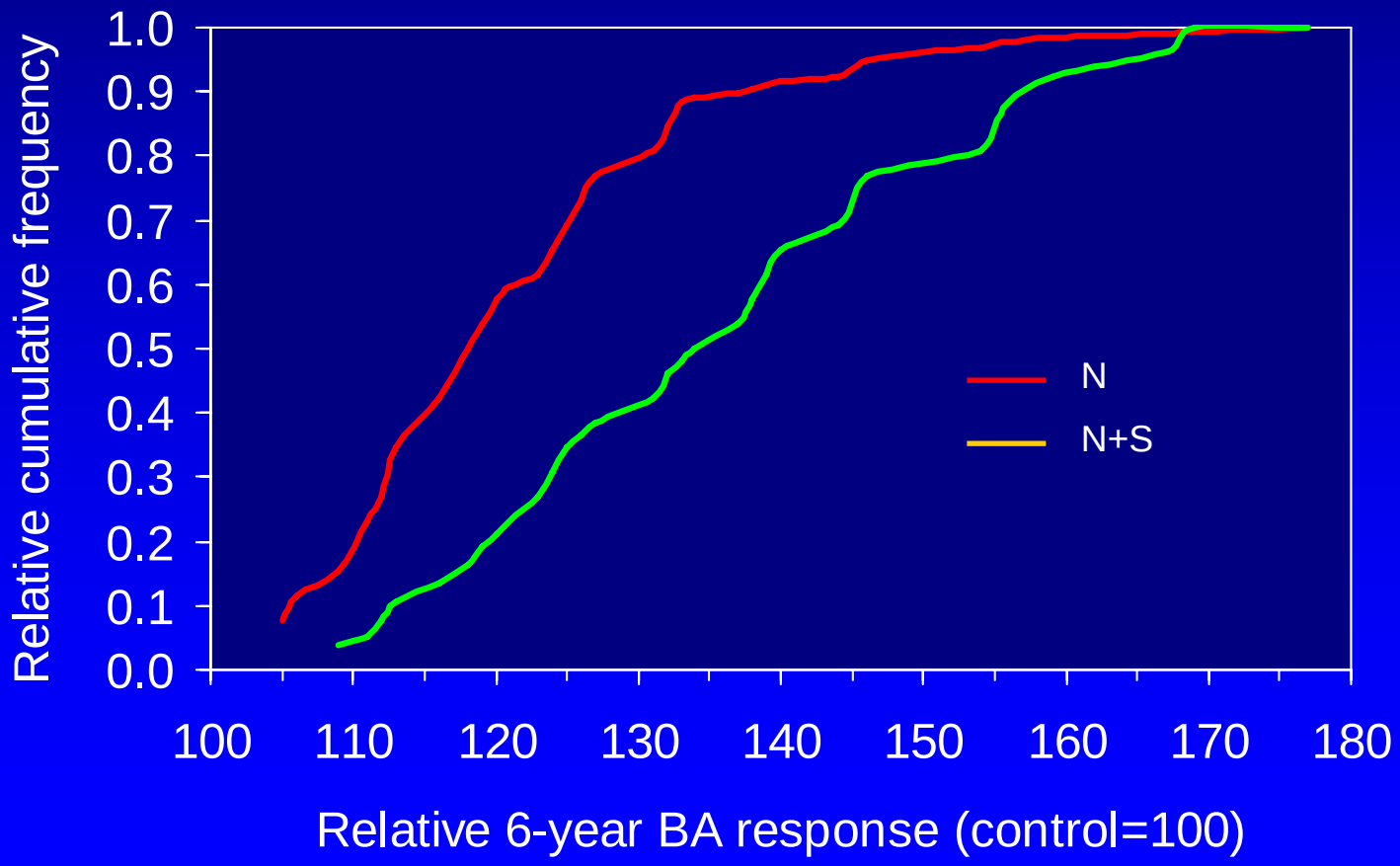
Effect of N and N+S fertilization on foliar N/S ratio

EP 886.09 (n=7)



BA response following N and N+S fertilization

Relative cumulative frequency distribution (n=26)



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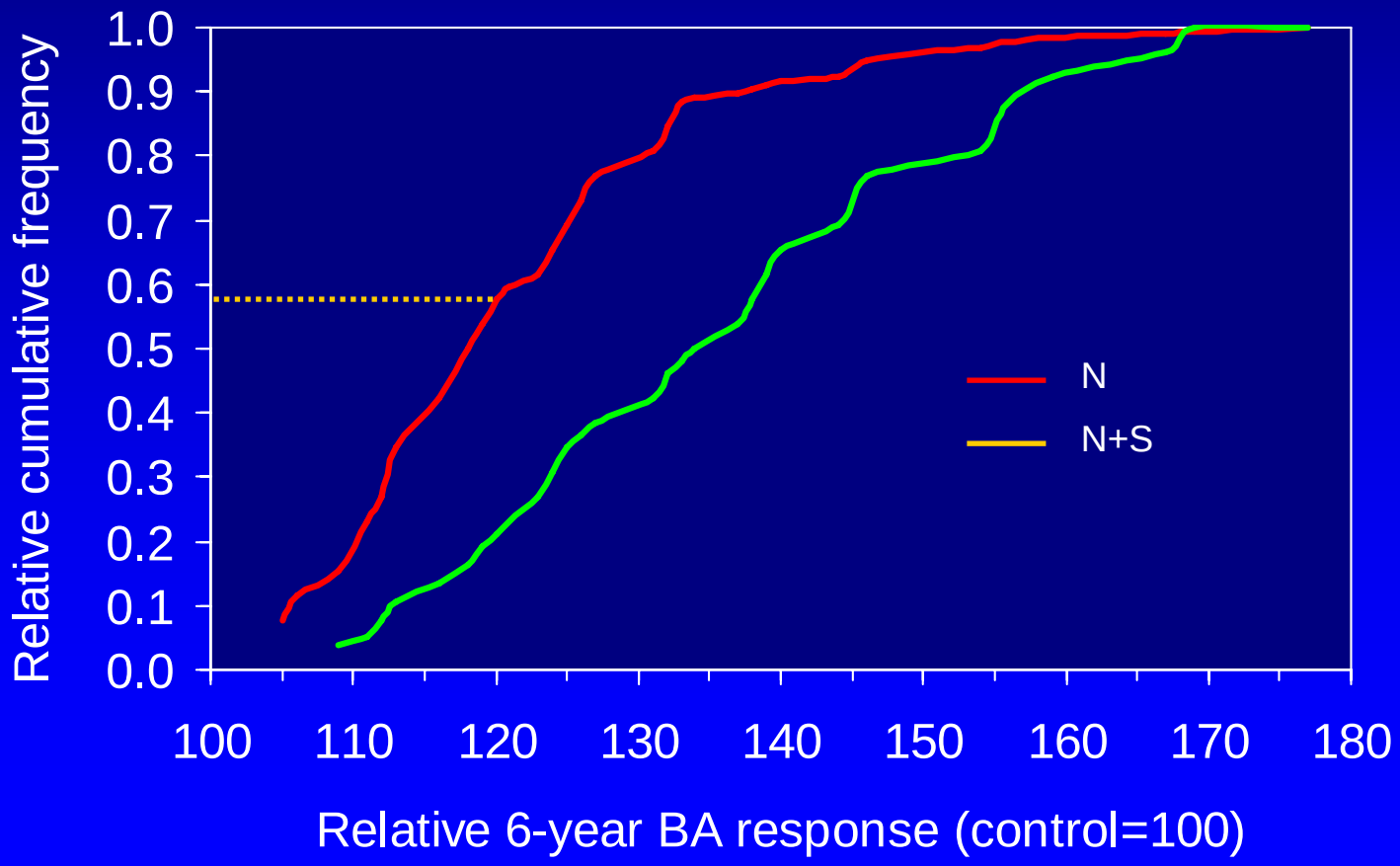

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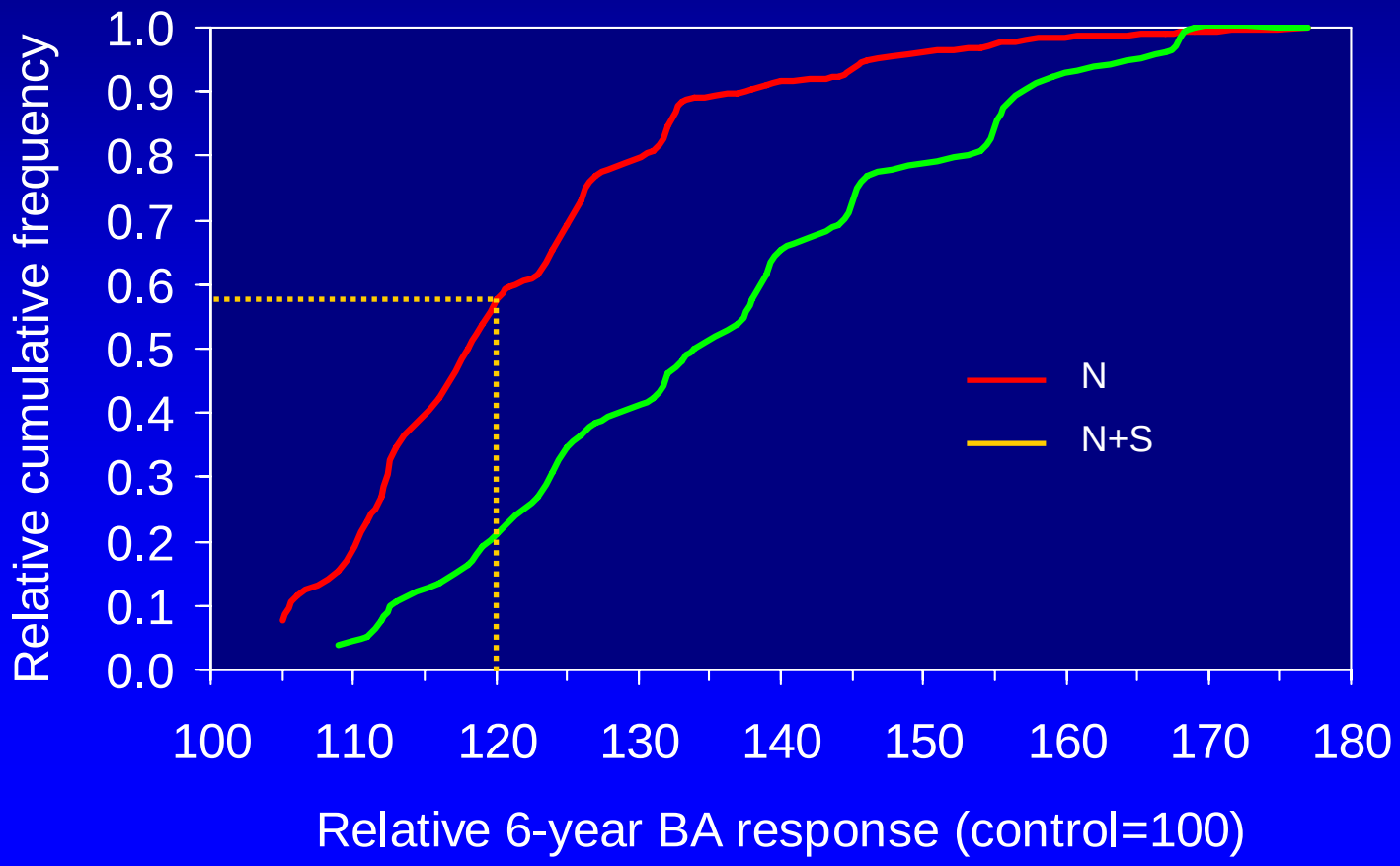

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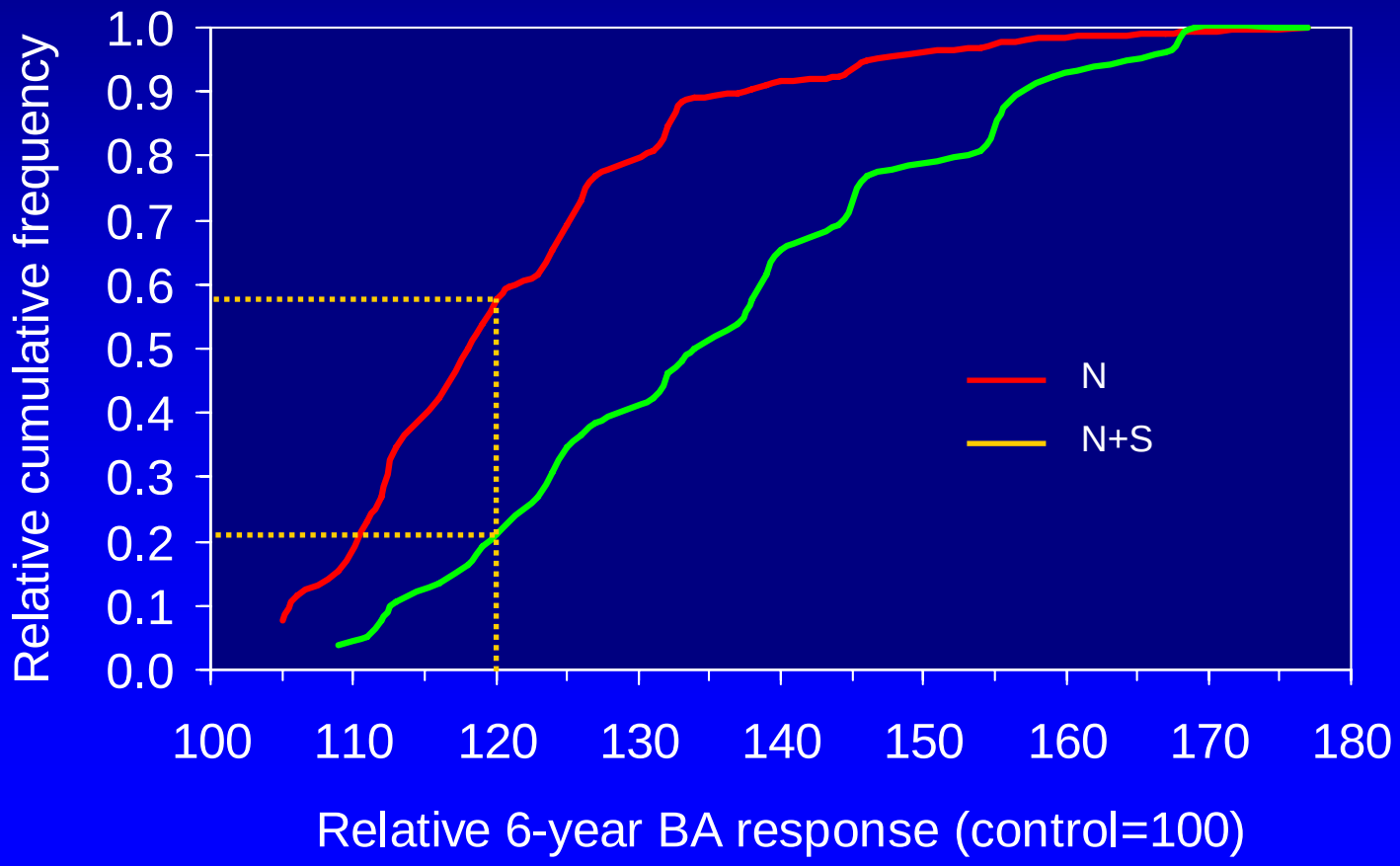

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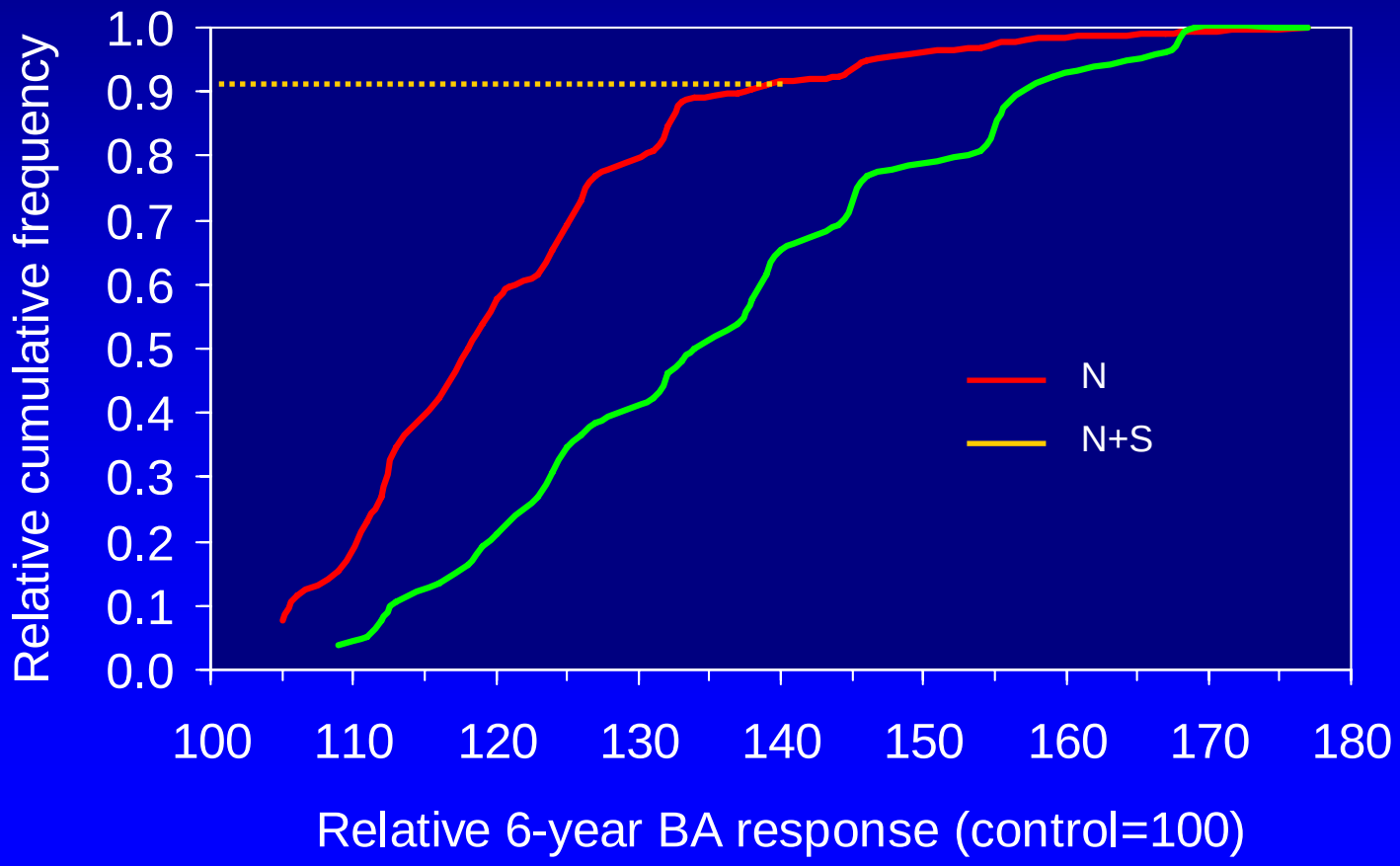

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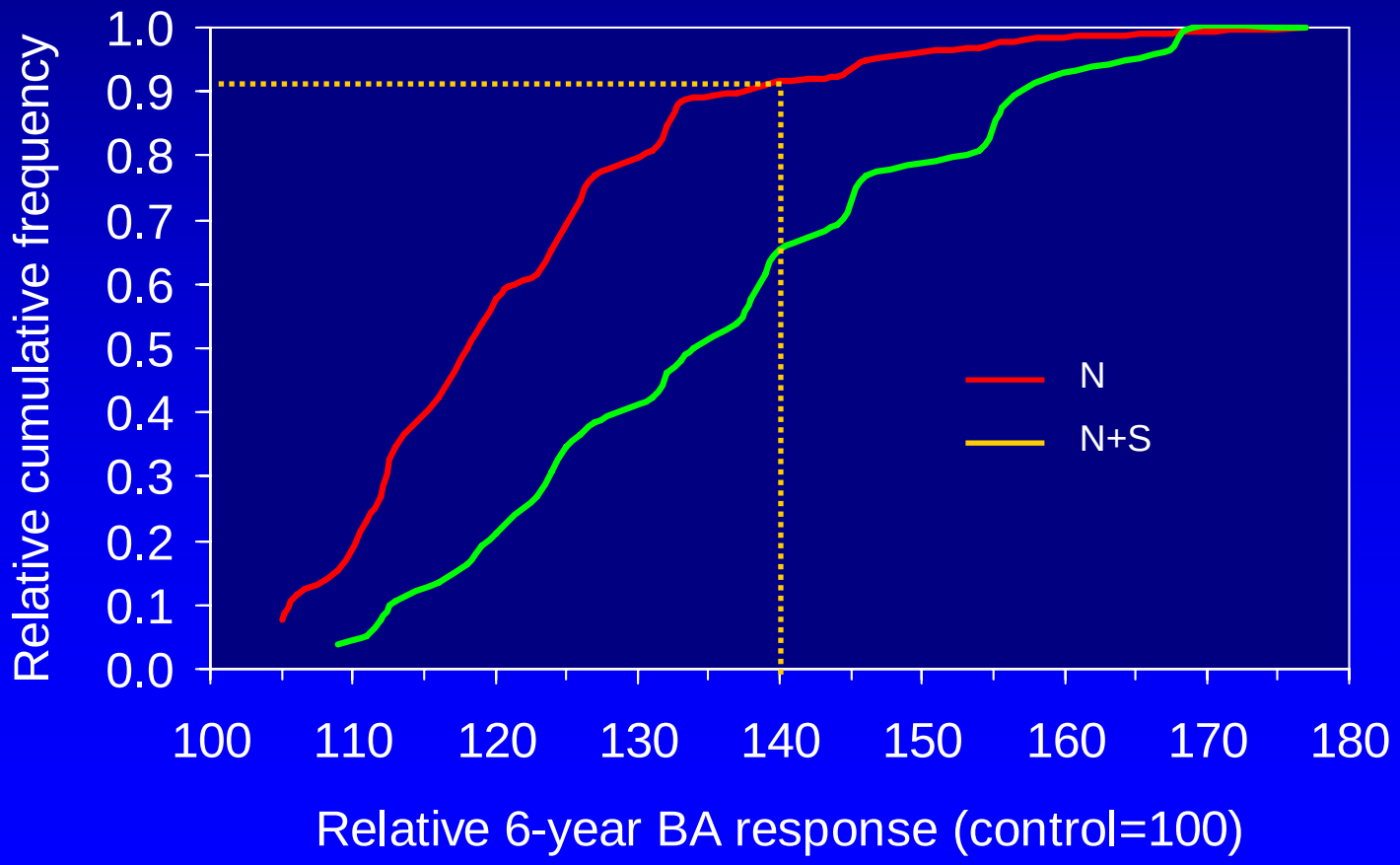

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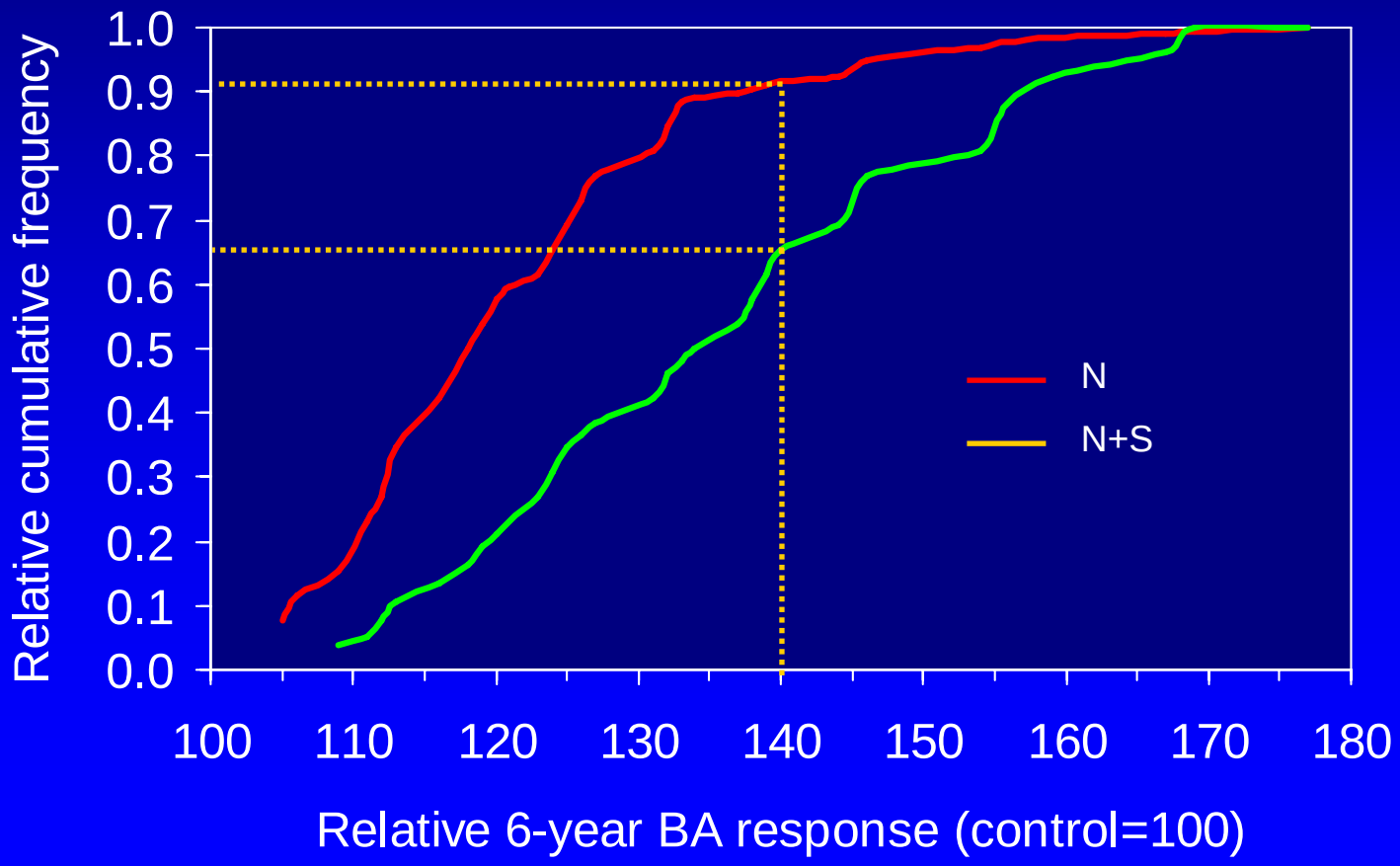
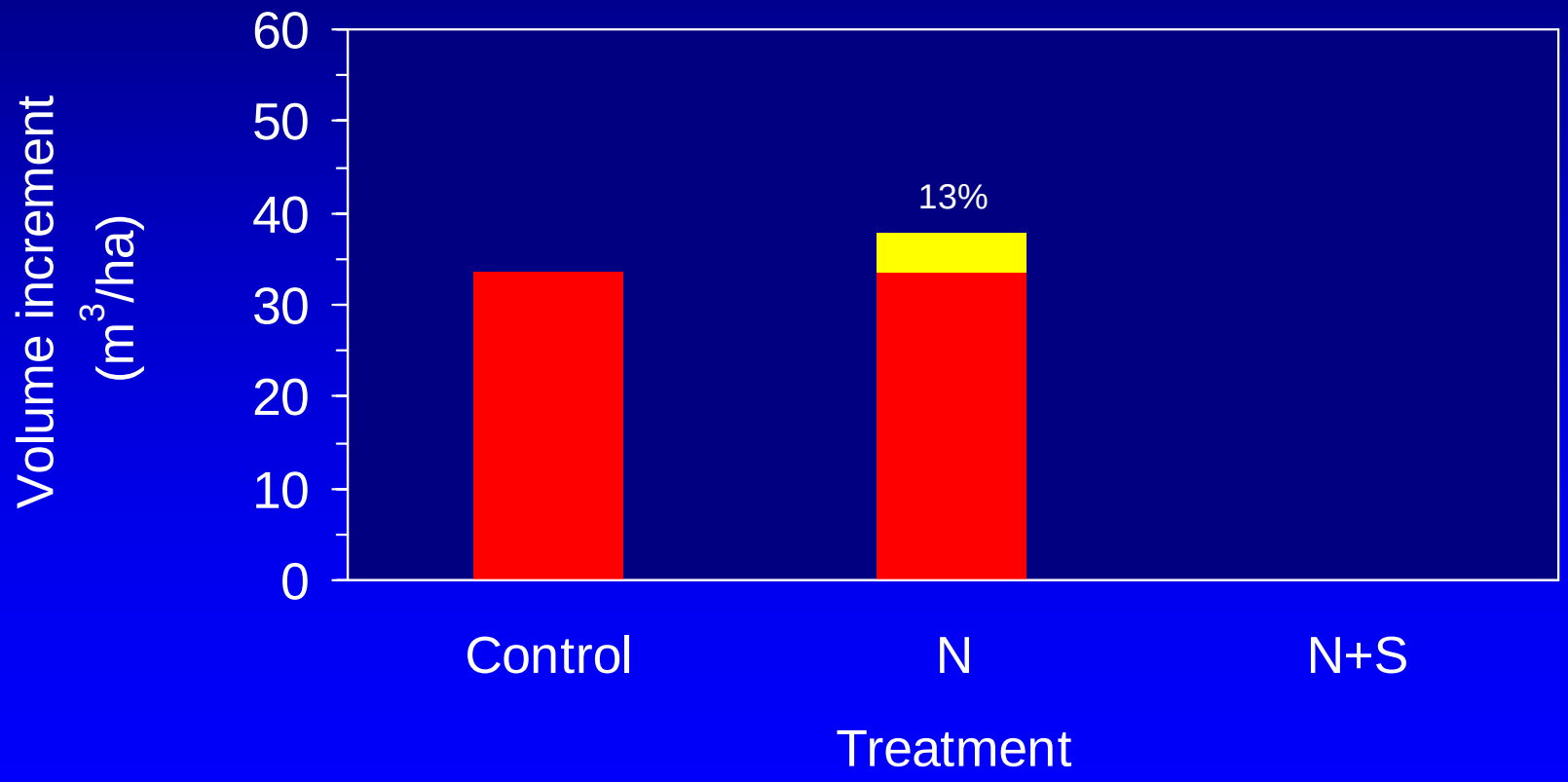


Effect of N and N+S fertilization on 6-year volume response of lodgepole pine in north-central B.C.

EP 886.01 (n=8)



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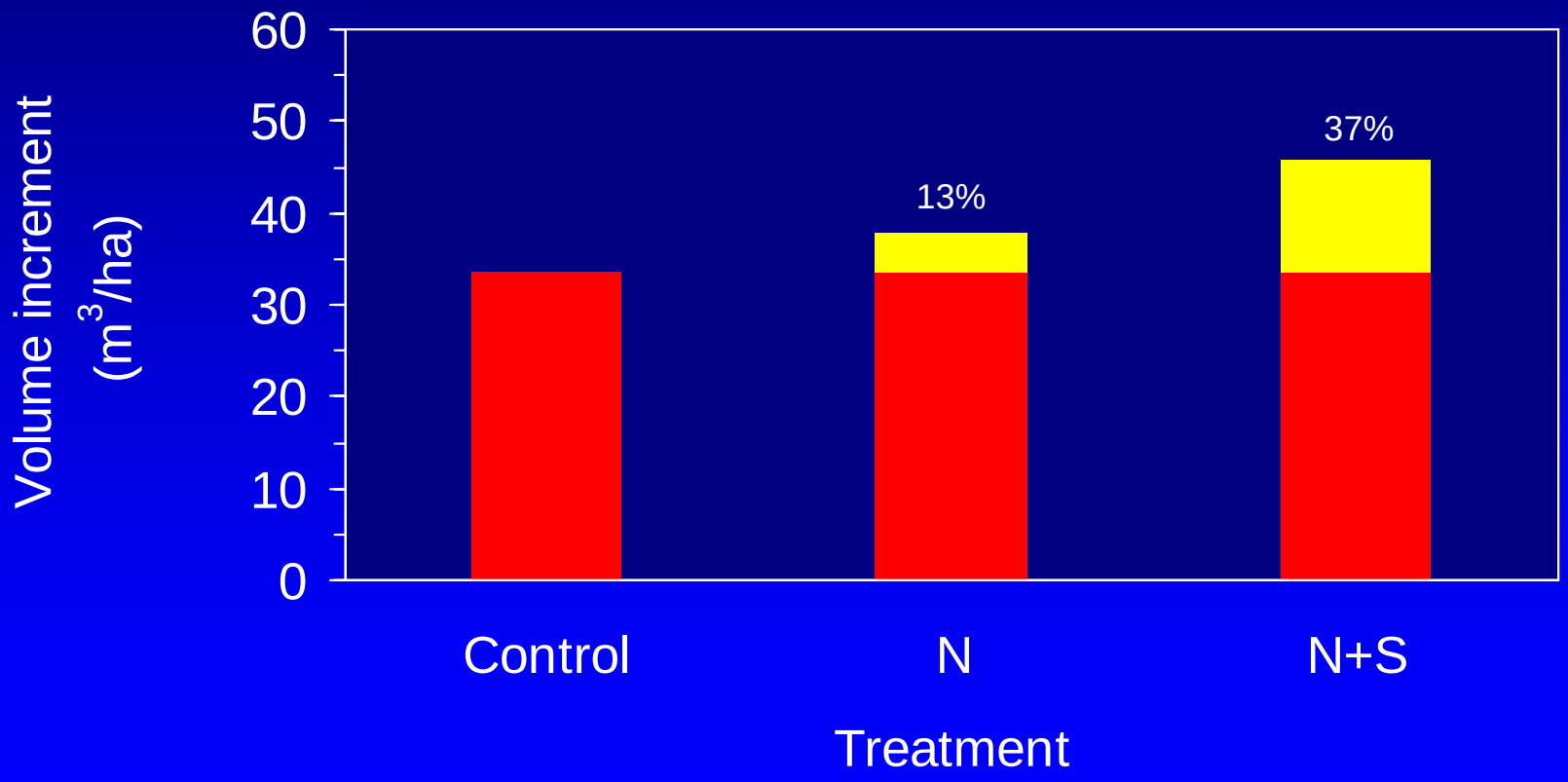
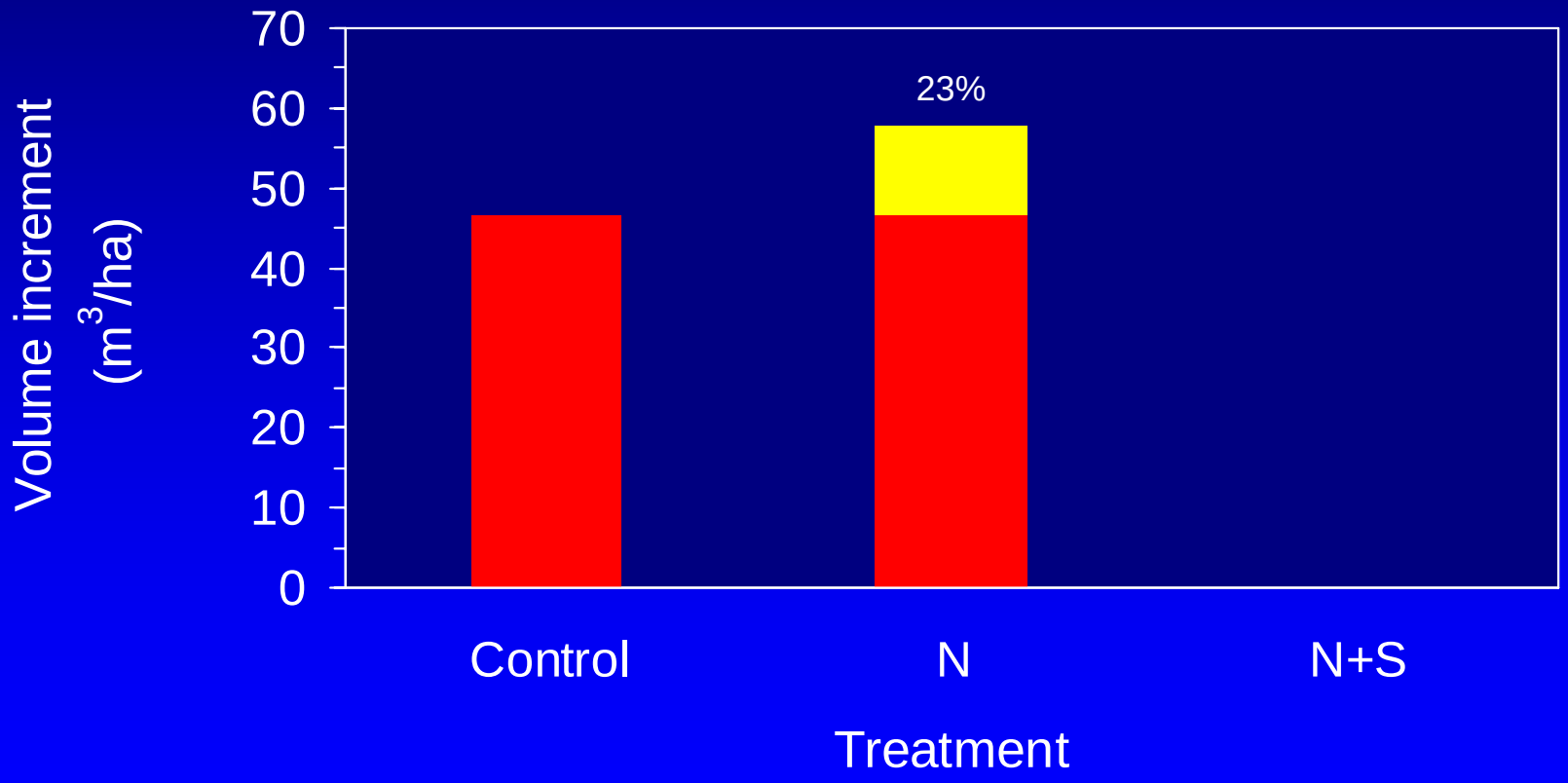


Effect of N and N+S fertilization on 6-year volume response of lodgepole pine in south-central B.C.

EP 886.01 (n=7)



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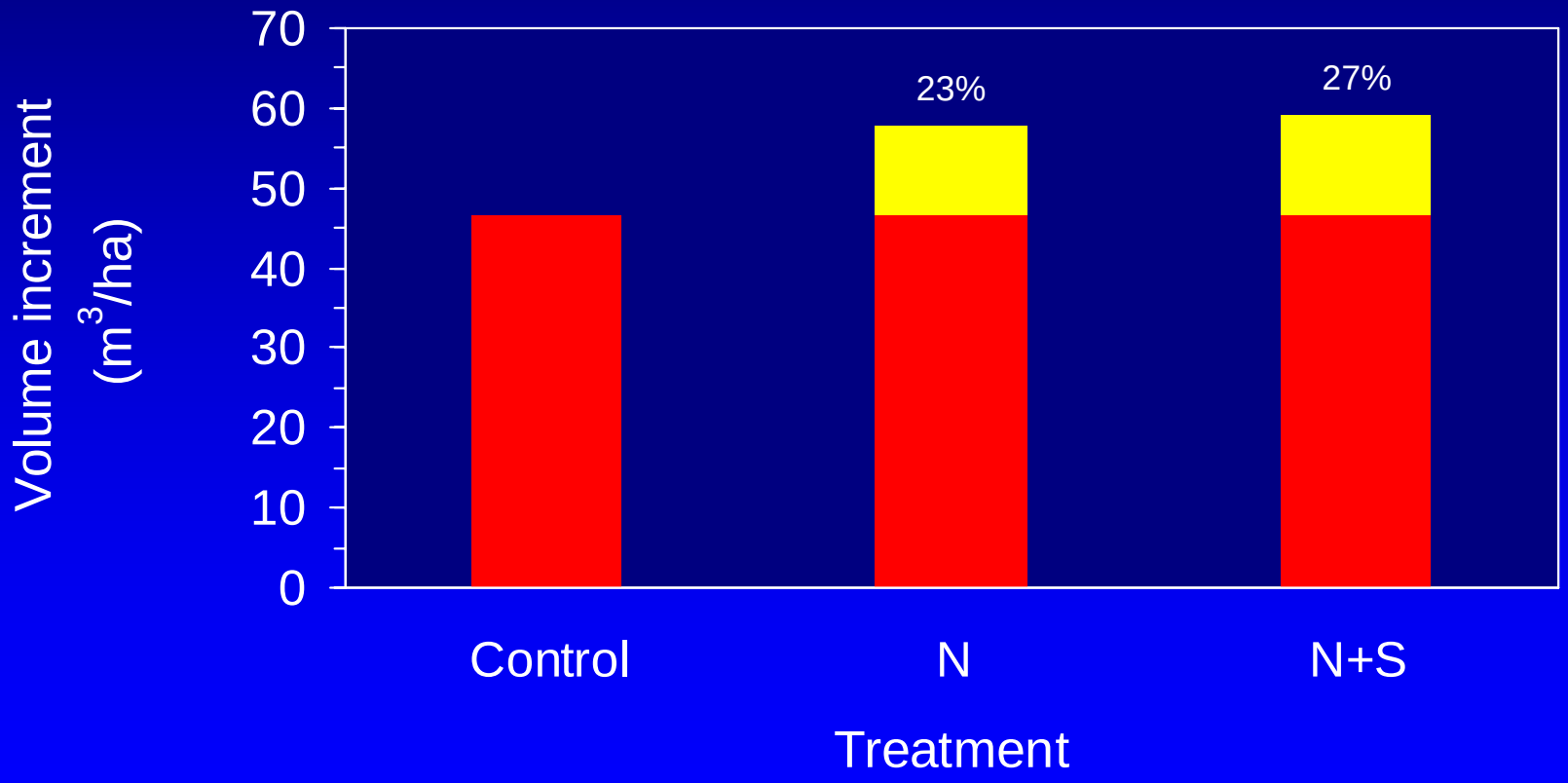
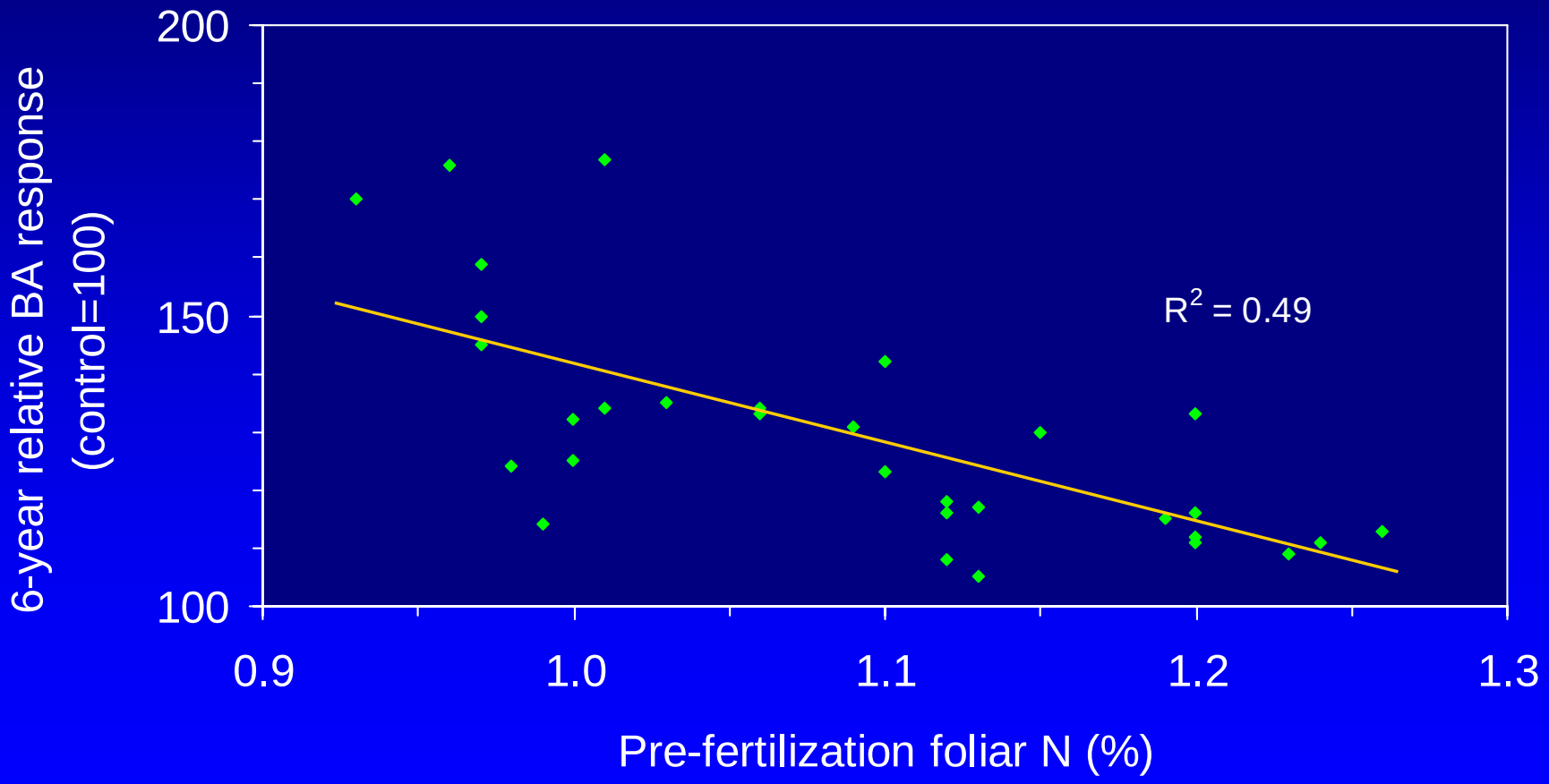
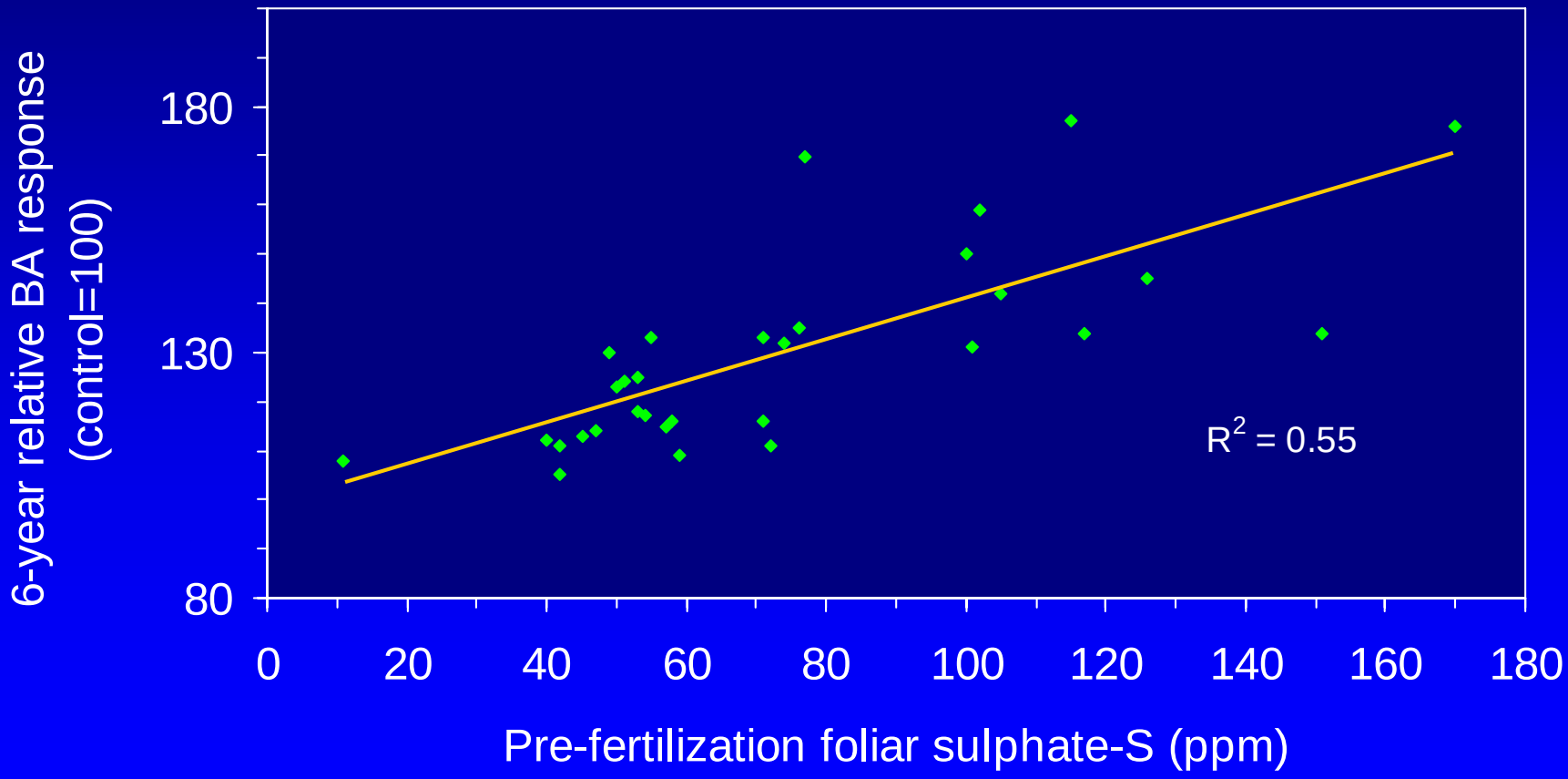
EP 886.01 (n=7)



6-year relative BA response vs. initial foliar N

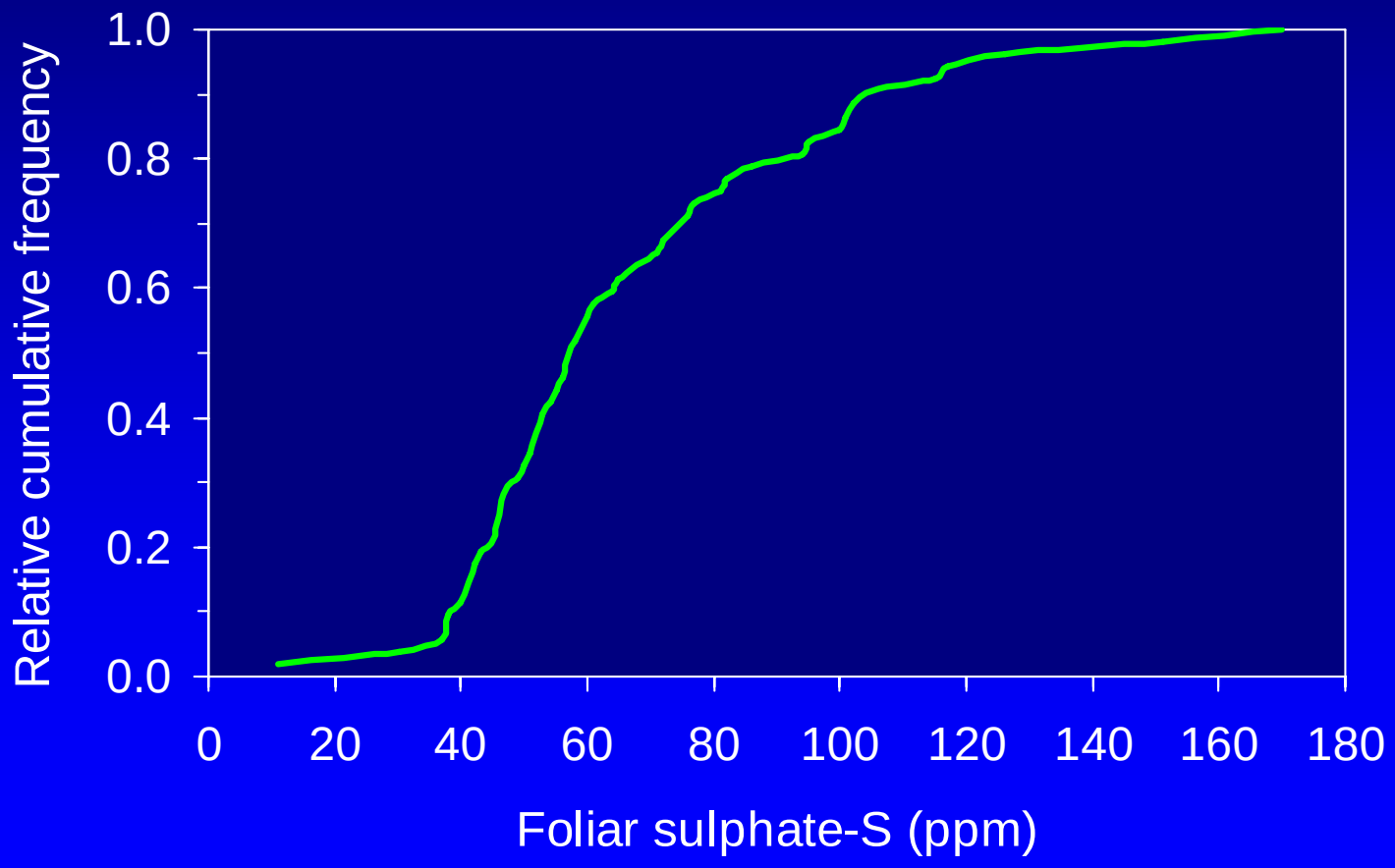


6-year relative BA response vs. initial foliar SO_4



Lodgepole pine foliar SO_4-S concentration

Relative cumulative frequency distribution (n=58)



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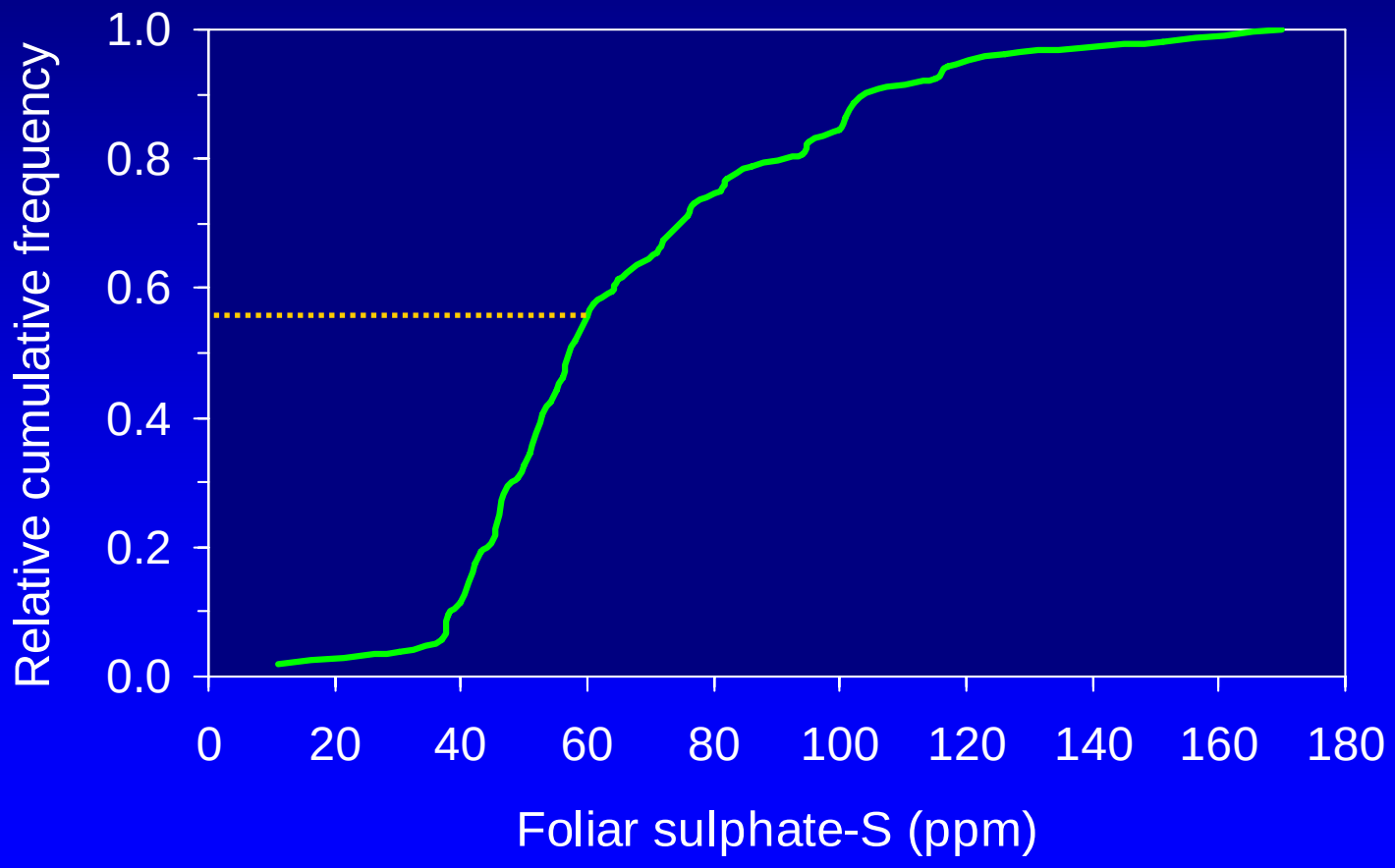

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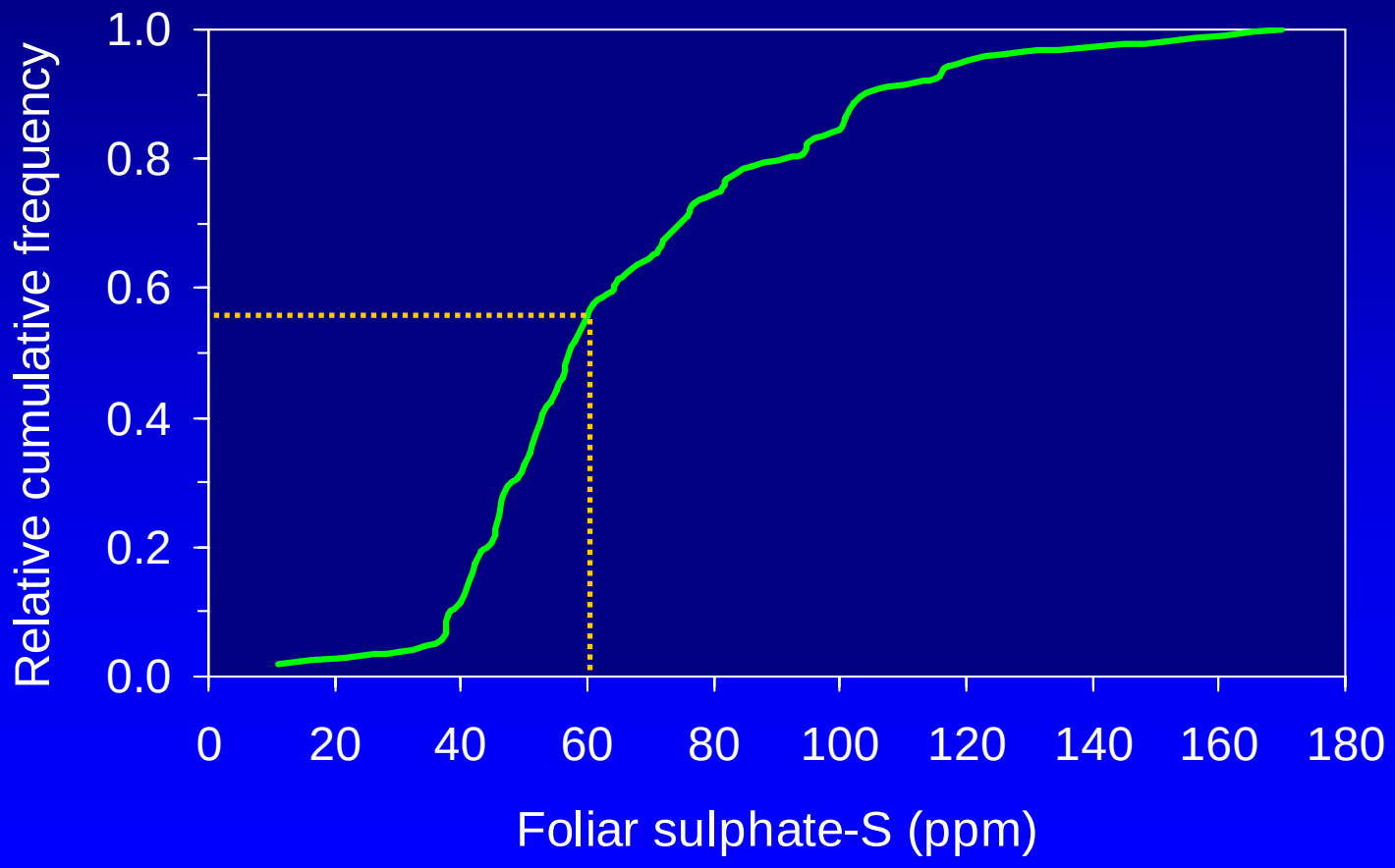

Lodgepole pine foliar boron concentration

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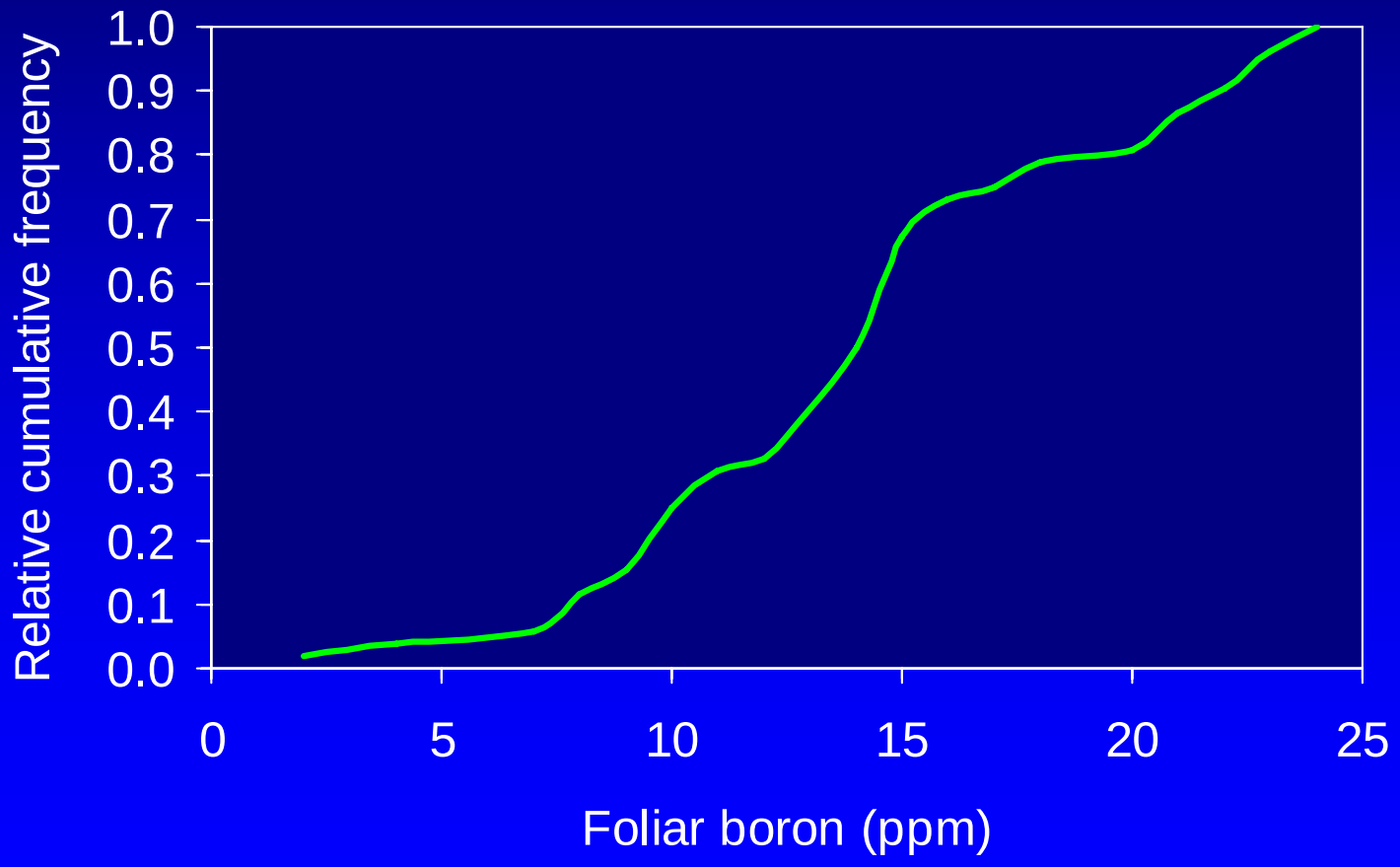

Lodgepole pine foliar boron concentration

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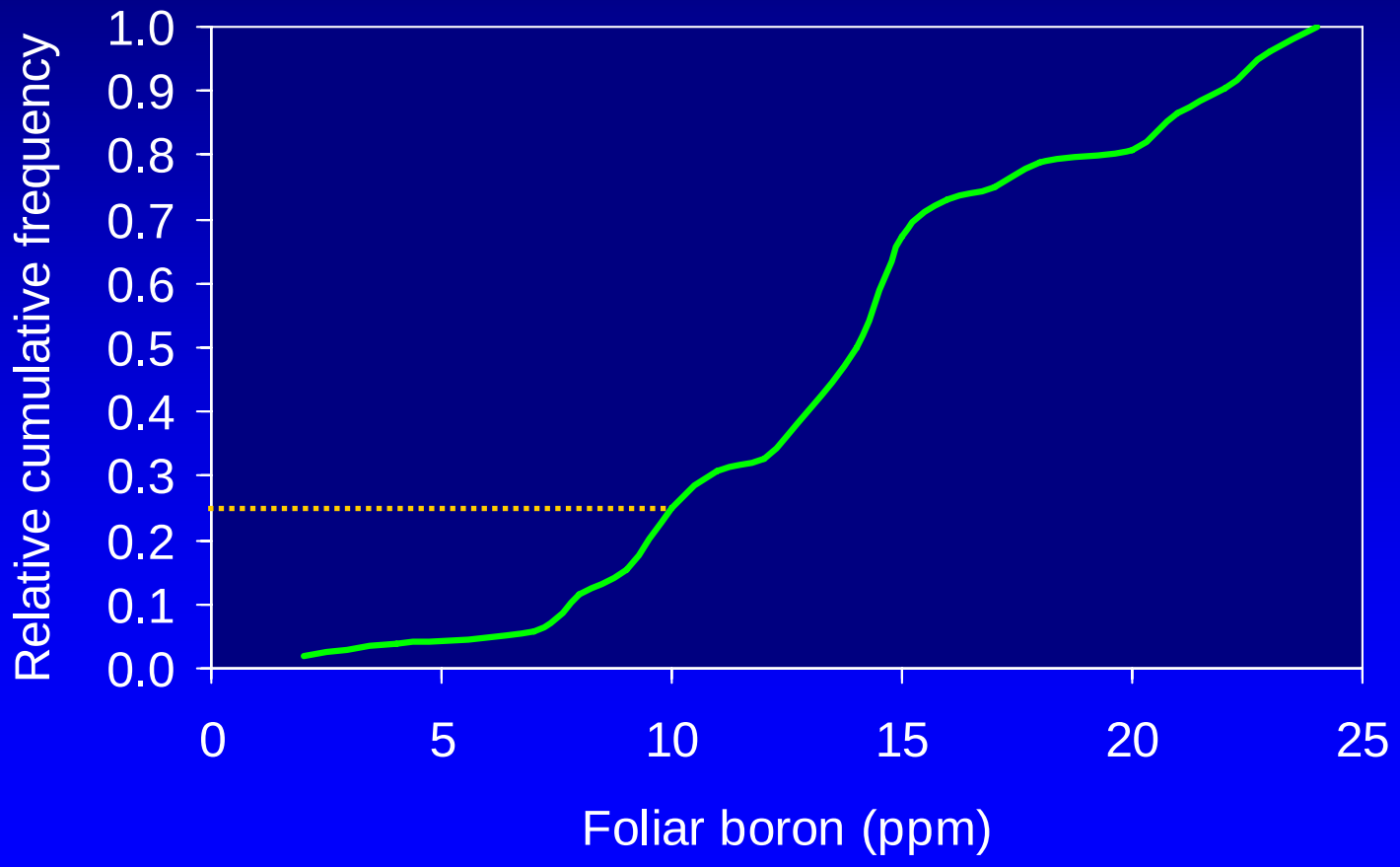

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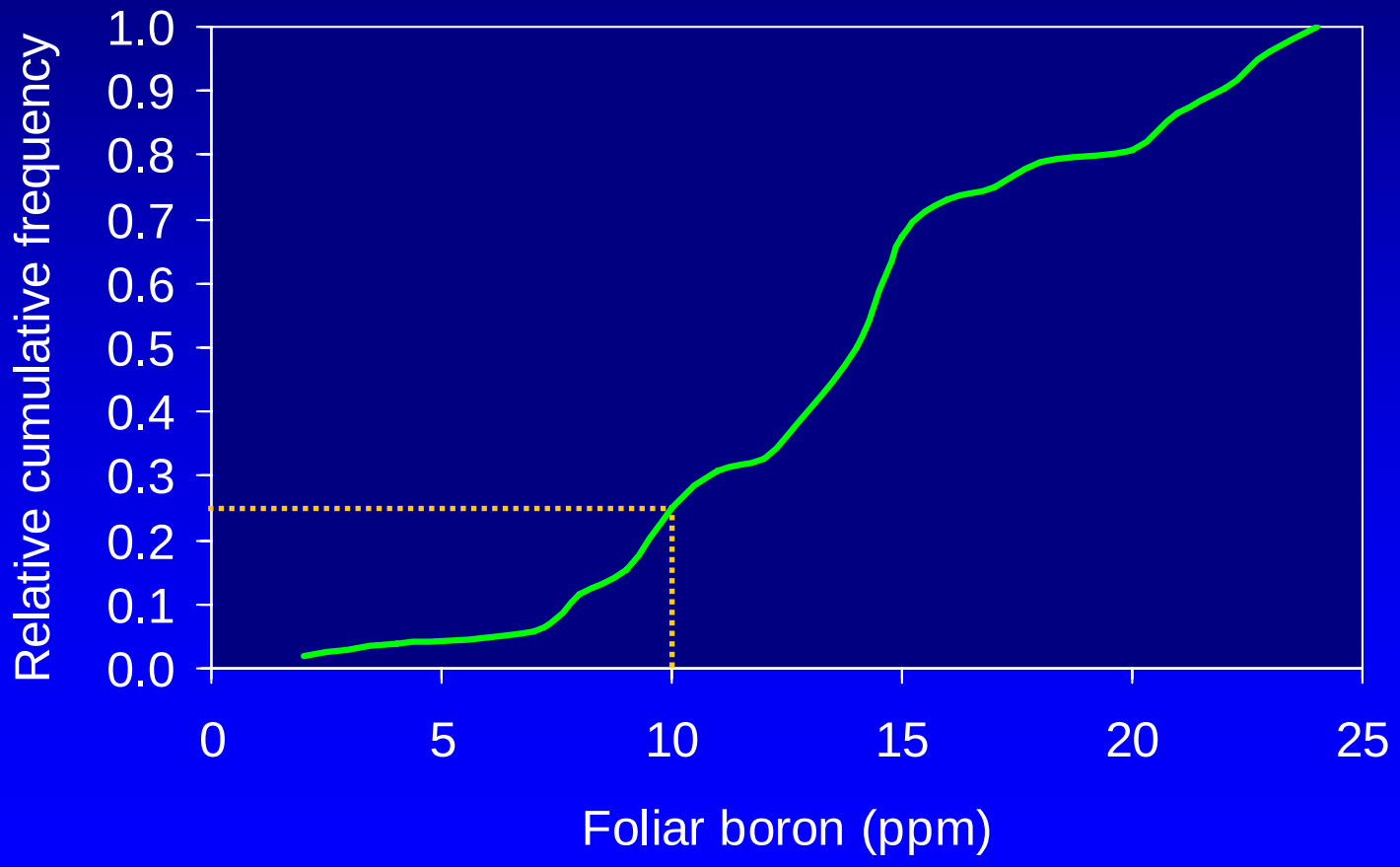
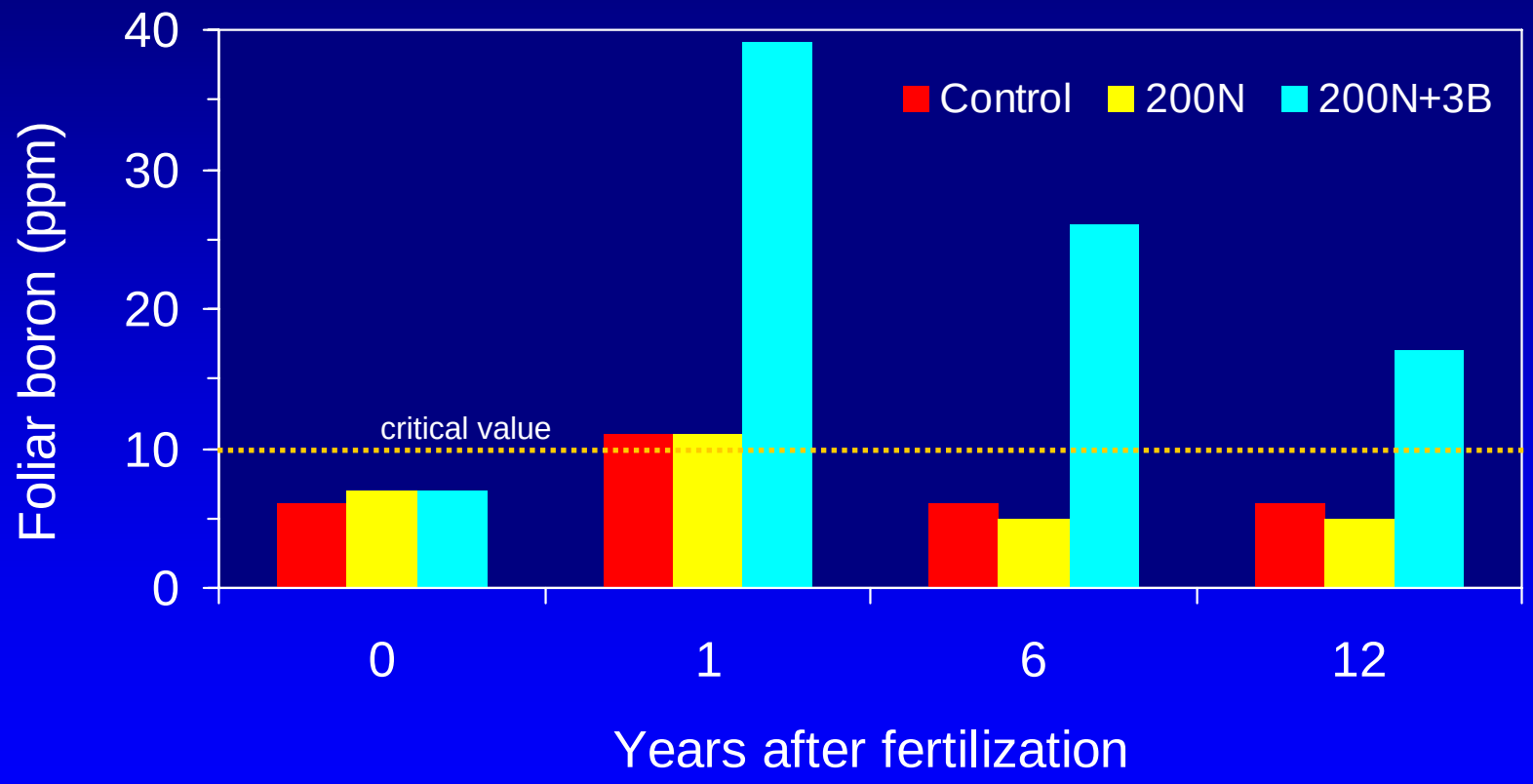


Effects of N and B fertilization on foliar B concentration

EP 886.05



Pl fertilization response in TIPSY (m^3/ha)

Planted: 1600 st/ha OAF1 & 2 = 1.00 Fert. Effectiveness = 80%

SI_{50} (m)	Age @ fertilization			
	15	20	25	30
16	5	7	11	13
18	7	12	15	18
20	10	16	20	21
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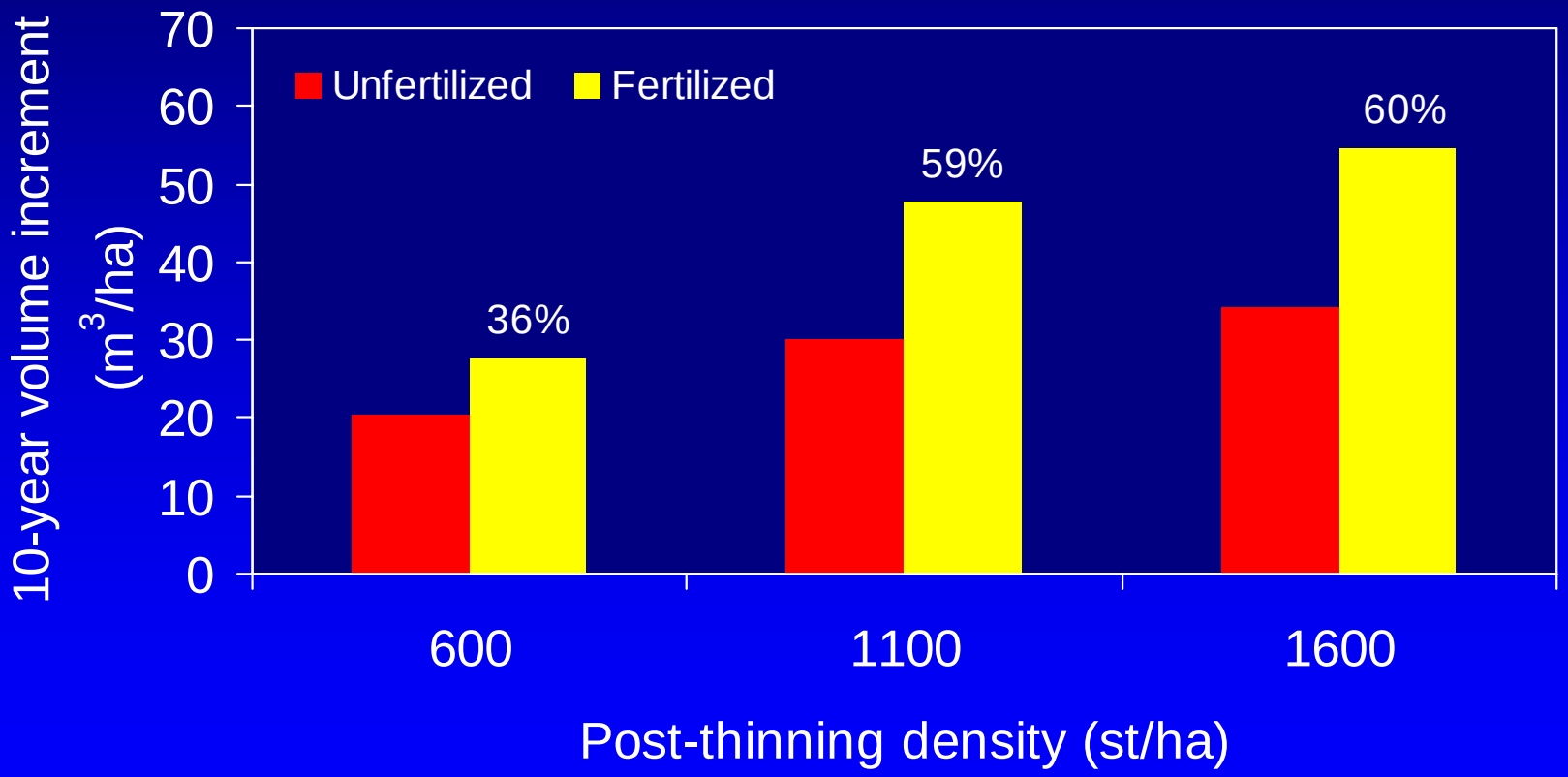
Effects of post-thinning stand density on the growth of unfertilized and fertilized lodgepole pine

EP 886.01 Inst. #16 (Brockley 2005)



Summary

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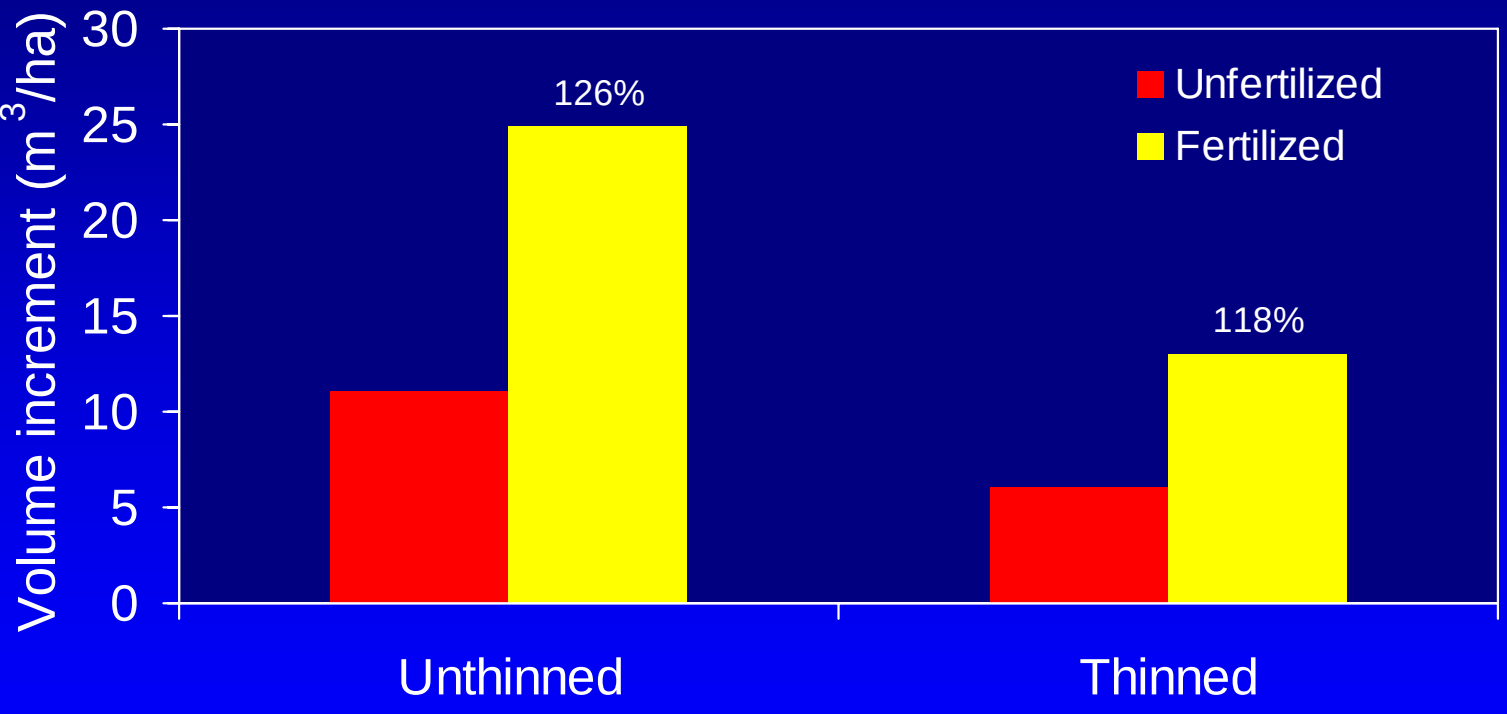
- combined application of N and S often improves growth response
- available foliar diagnostic criteria and predictive tools reduce uncertainty regarding fertilizer operations

Fertilization of repressed lodgepole pine

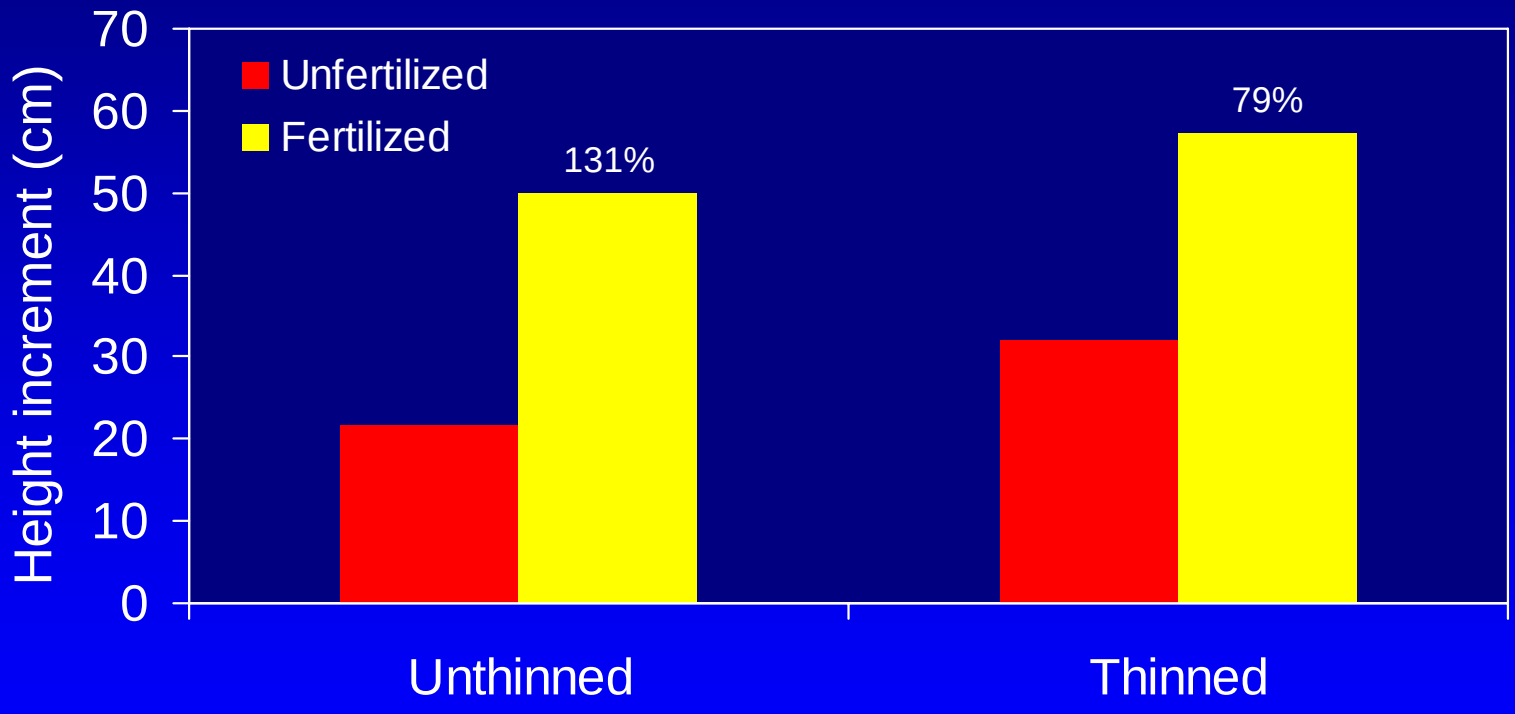
Fertilization of 36-year-old repressed lodgepole pine: 4-year volume increment (all trees)

Blevins et al. (2005)



Fertilization of 36-year-old repressed lodgepole pine: 4-year height increment (all trees)

Blevins et al. (2005)



Subalpine fir fertilization

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- Fertilization of subalpine forests may be a potentially viable timber supply mitigation strategy
- Several *Abies* species (grand fir, red fir, white fir, noble fir) respond well to fertilization
- Reliable fertilization response information for subalpine fir is virtually non-existent

Blunt fire retrospective fertilization assessment

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- ~ 60- to 70-year-old naturally regenerated subalpine fir
- 950 ha operationally thinned (1997 and 1998) and fertilized (2000 to 2003)
- Cooperators: MoFR, West Fraser, Silvicon

What caused the growth response?

How is fertilization response measured?

- R_f =

  where:

  R_f = growth response of a fertilized tree

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  where:

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- $R_f = A_f - E_f$

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  where:

  R_f = growth response of a fertilized tree

  A_f = post-fertilization growth of a fertilized tree

  E_f = growth that would have occurred had tree not been fertilized

- E_f can only be estimated (i.e., cannot be measured)

How is fertilization response measured?

- $R_f = A_f - A_u$

  where:

  R_f = growth response of a fertilized tree

  A_f = post-fertilization growth of a fertilized tree

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$R_f = A_f - A_u$


Unfertilized
U10
Year of fertilization
Au
Fertilized
F23
Year of fertilization
Af

How is fertilization response measured?

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  where:

  R_f = growth response of a fertilized tree

  A_f = post-fertilization growth of a fertilized tree

  A_u = post-fertilization growth of an unfertilized tree

- A_u may be a poor estimate of E_f because of stand and site differences between the unfertilized and fertilized stands

How is fertilization response measured?

- $R_f = A_f - B_f$

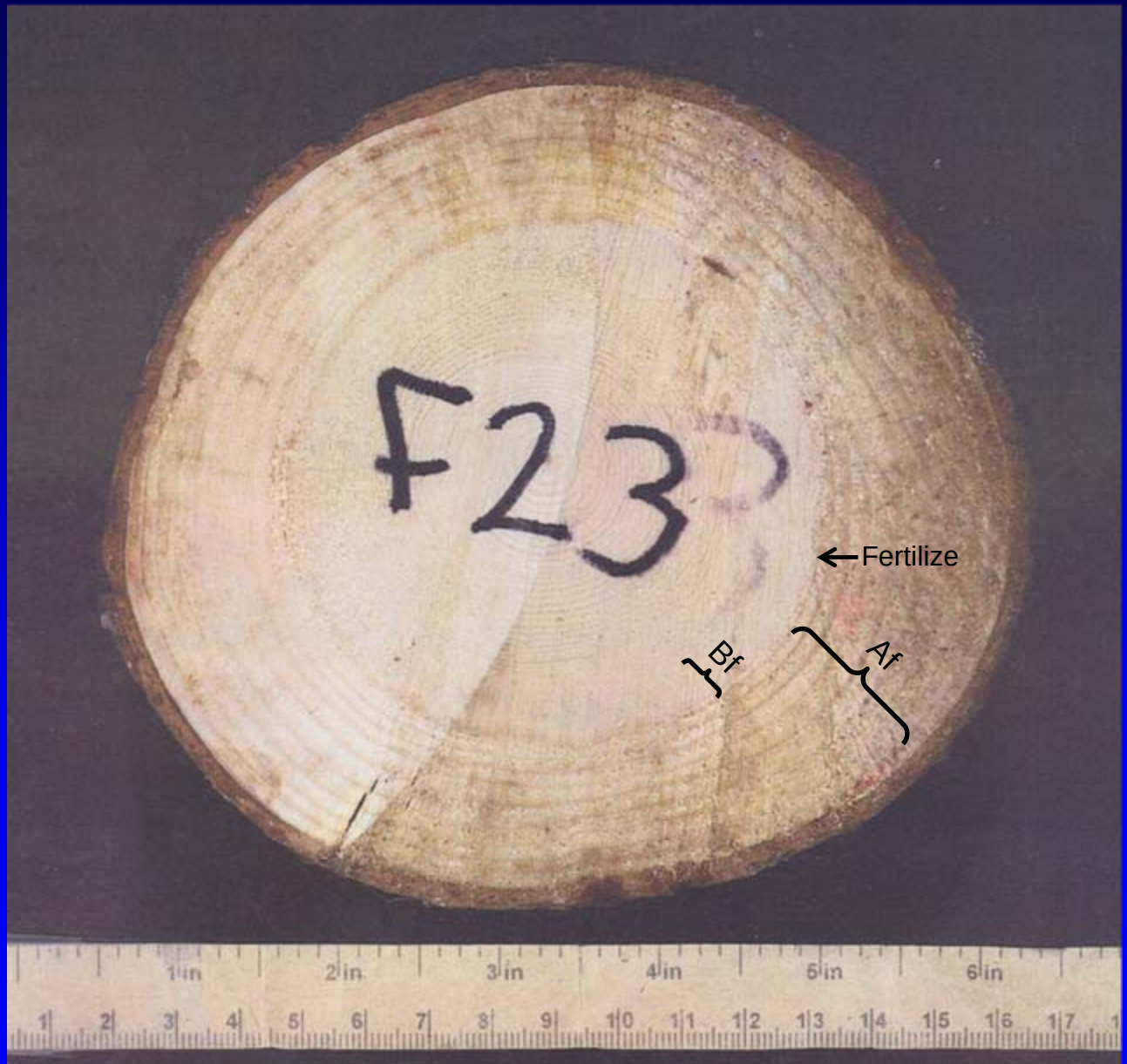
  where:

  R_f = growth response of a fertilized tree

  A_f = post-fertilization growth of a fertilized tree

  B_f = pre-fertilization growth of a fertilized tree

$R_f = A_f - B_f$



How is fertilization response measured?

- $R_f = A_f - B_f$

  where:

  R_f = growth response of a fertilized tree

  A_f = post-fertilization growth of a fertilized tree

  B_f = pre-fertilization growth of a fertilized tree

- B_f may be a poor estimate of E_f because of climatic differences between pre- and post-fertilization periods and other treatment effects (e.g., thinning)

How is fertilization response measured?

- $R_f = A_f - (B_f)av(A_u/B_u)$

  where:

  R_f = growth response of a fertilized tree

  A_f = post-fertilization growth of a fertilized tree

  B_f = pre-fertilization growth of a fertilized tree

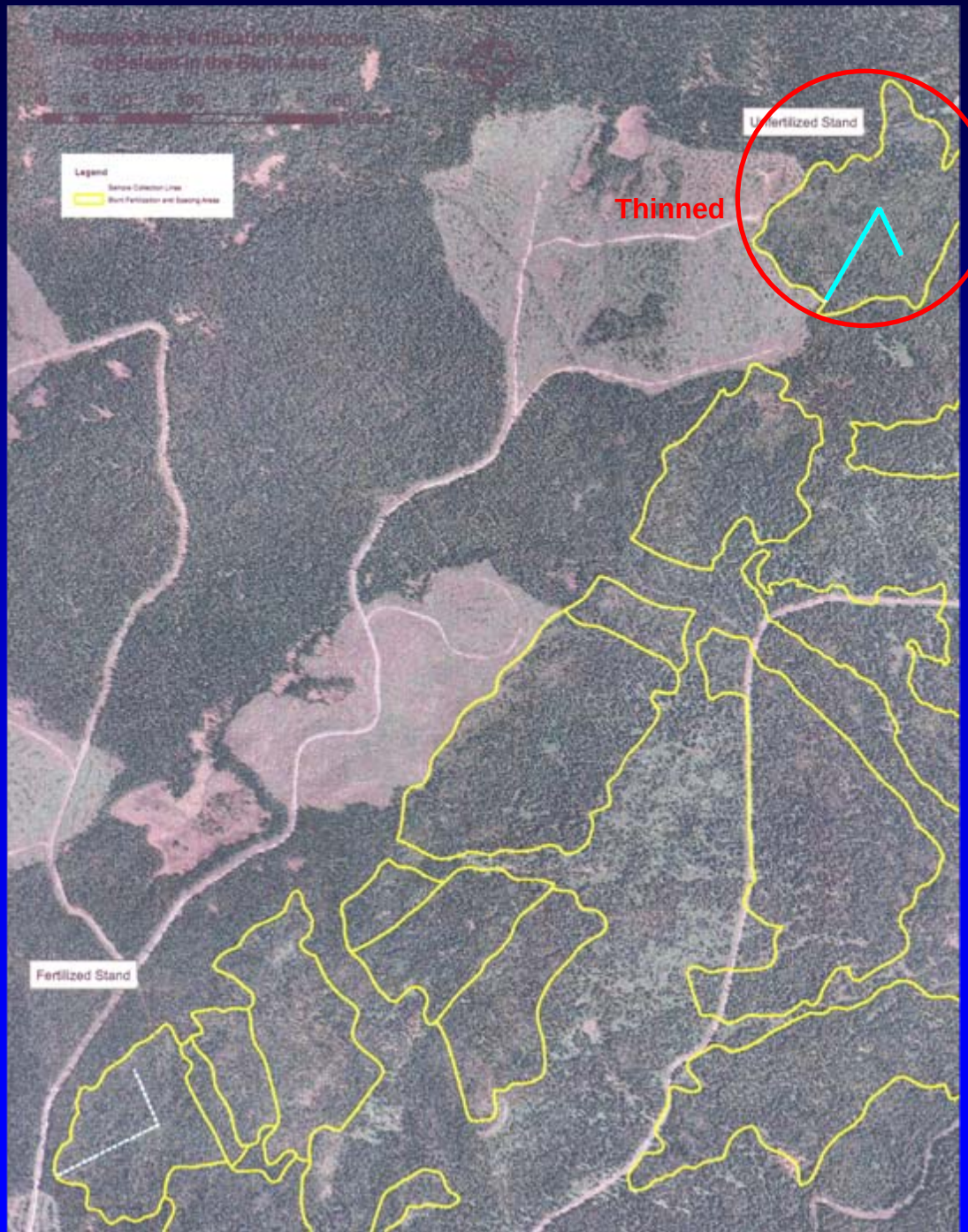
  A_u = post-fertilization growth of an unfertilized tree

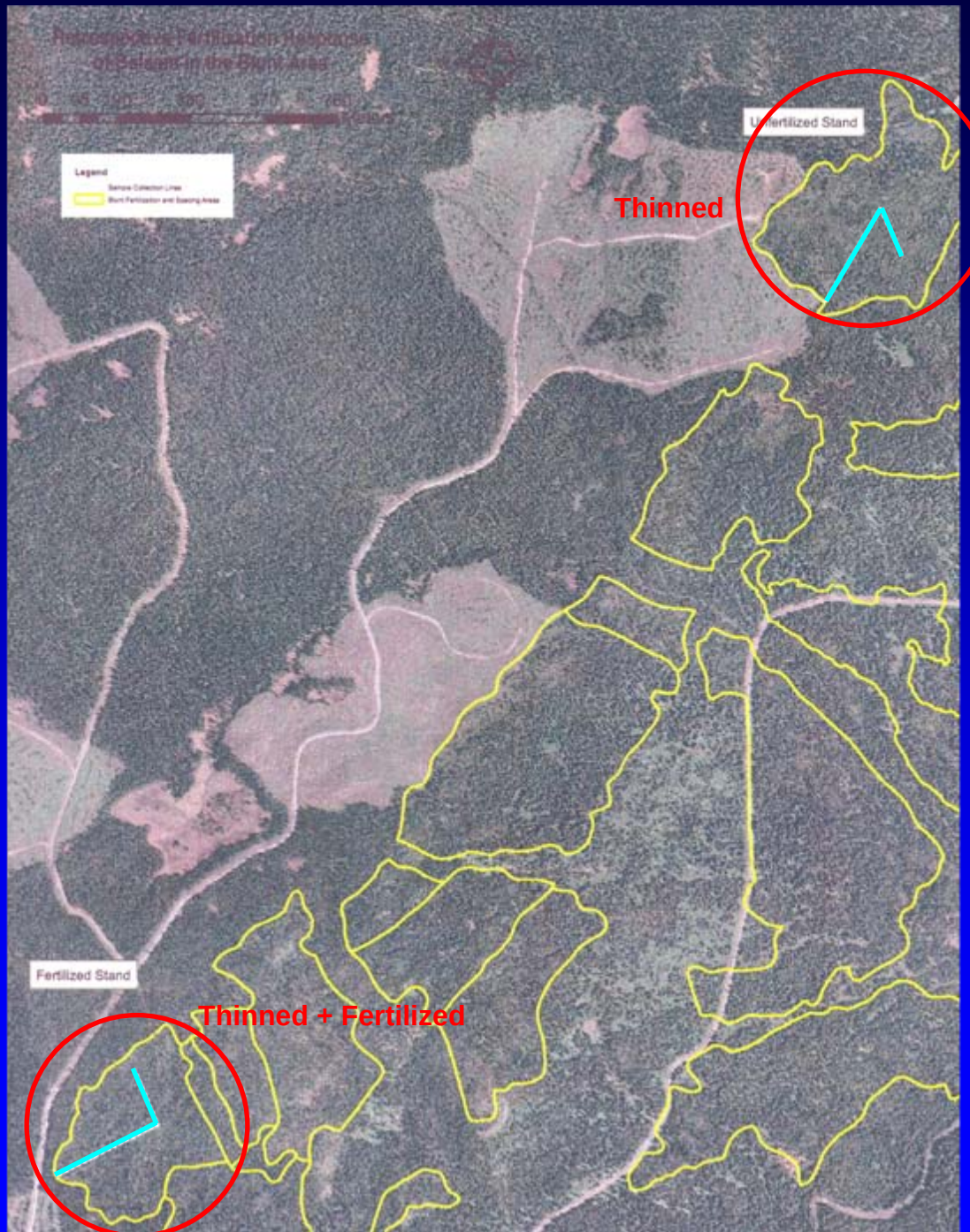
  B_u = pre-fertilization growth of an unfertilized tree

Field sampling methodology

Field sampling methodology

- Locate ~35 sampling points at paced intervals along transect lines in both a thinned and a thinned + fertilized stand


Unfertilized Stand
Thinned
Fertilized Stand


Unfertilized Stand
Thinned
Fertilized Stand
Thinned + Fertilized

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Planned fertilization assessment protocol

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Actual fertilization assessment protocol

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  - B_u and B_f = 7-year pre-fertilization mean radial growth (1994-2000) of trees in unfertilized and fertilized stands, respectively

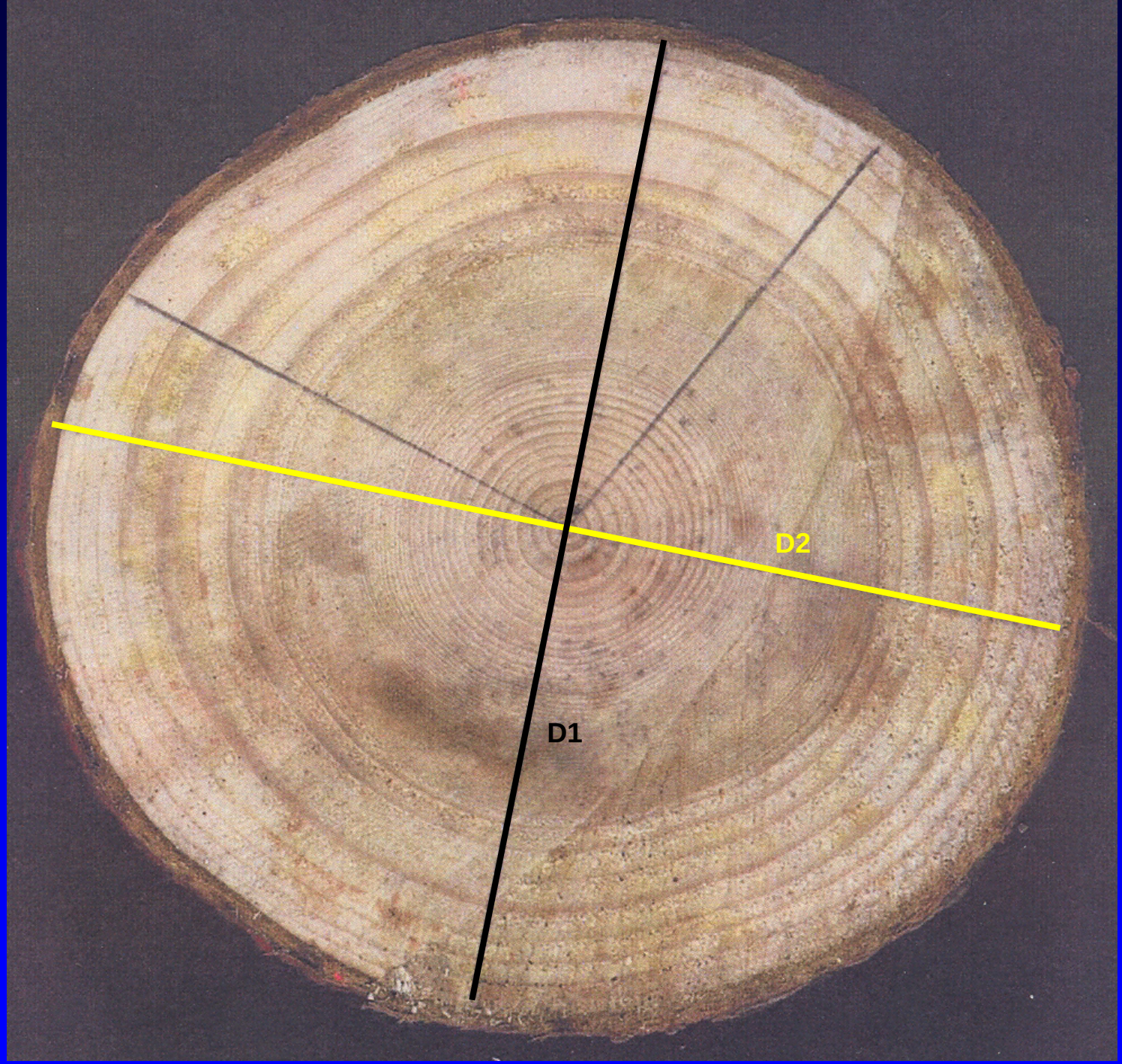
Disc measurement

- Measure the largest diameter (D1) on each disc


D1

Disc measurement

- Measure the largest diameter (D1) on each disc
- Measure the diameter (D2) of the perpendicular bisector of D1


D2
D1

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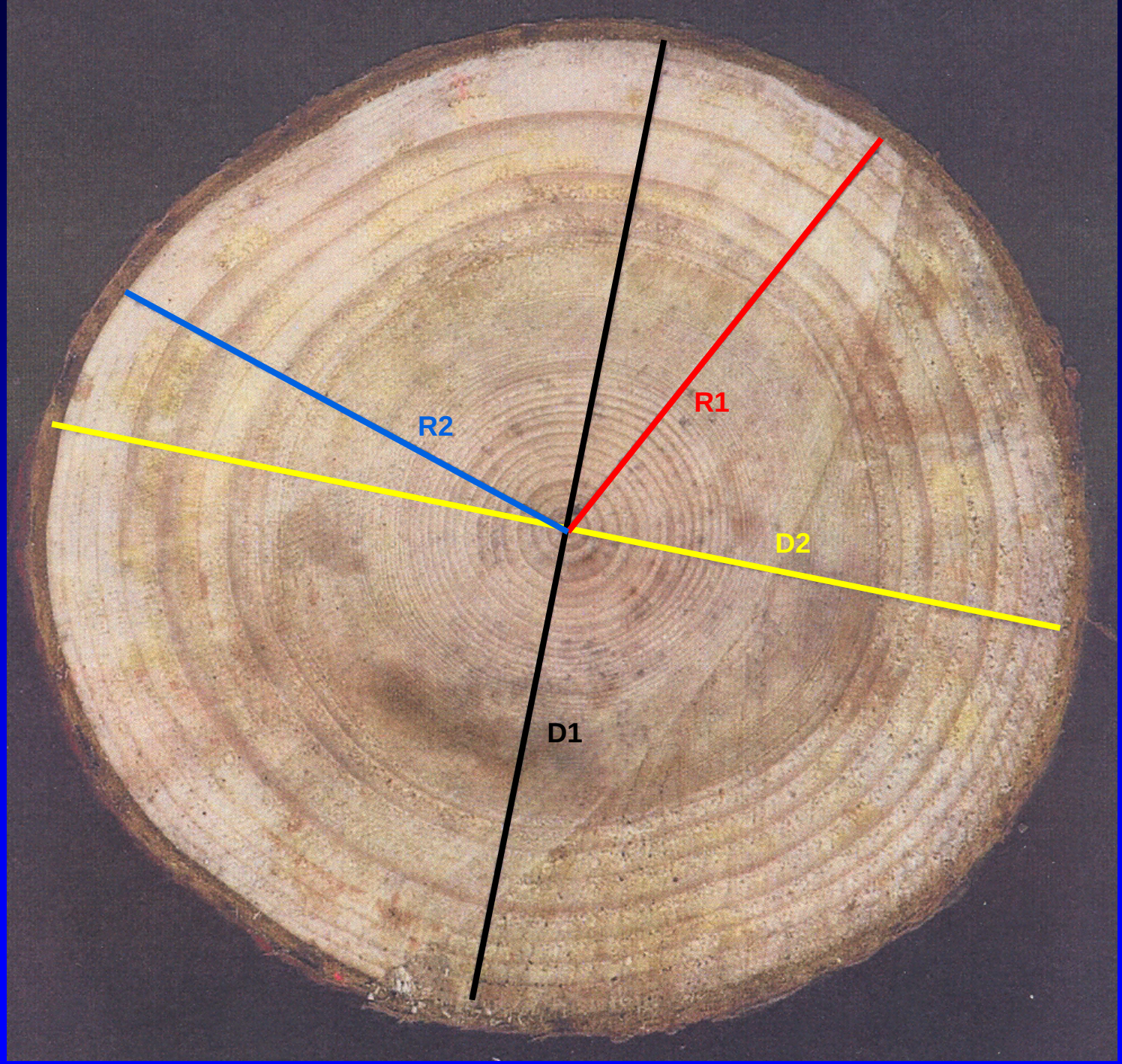
R2
R1
D2
D1

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  - Distance from pith to the outer edge of 1993 growth ring (year of thinning), X

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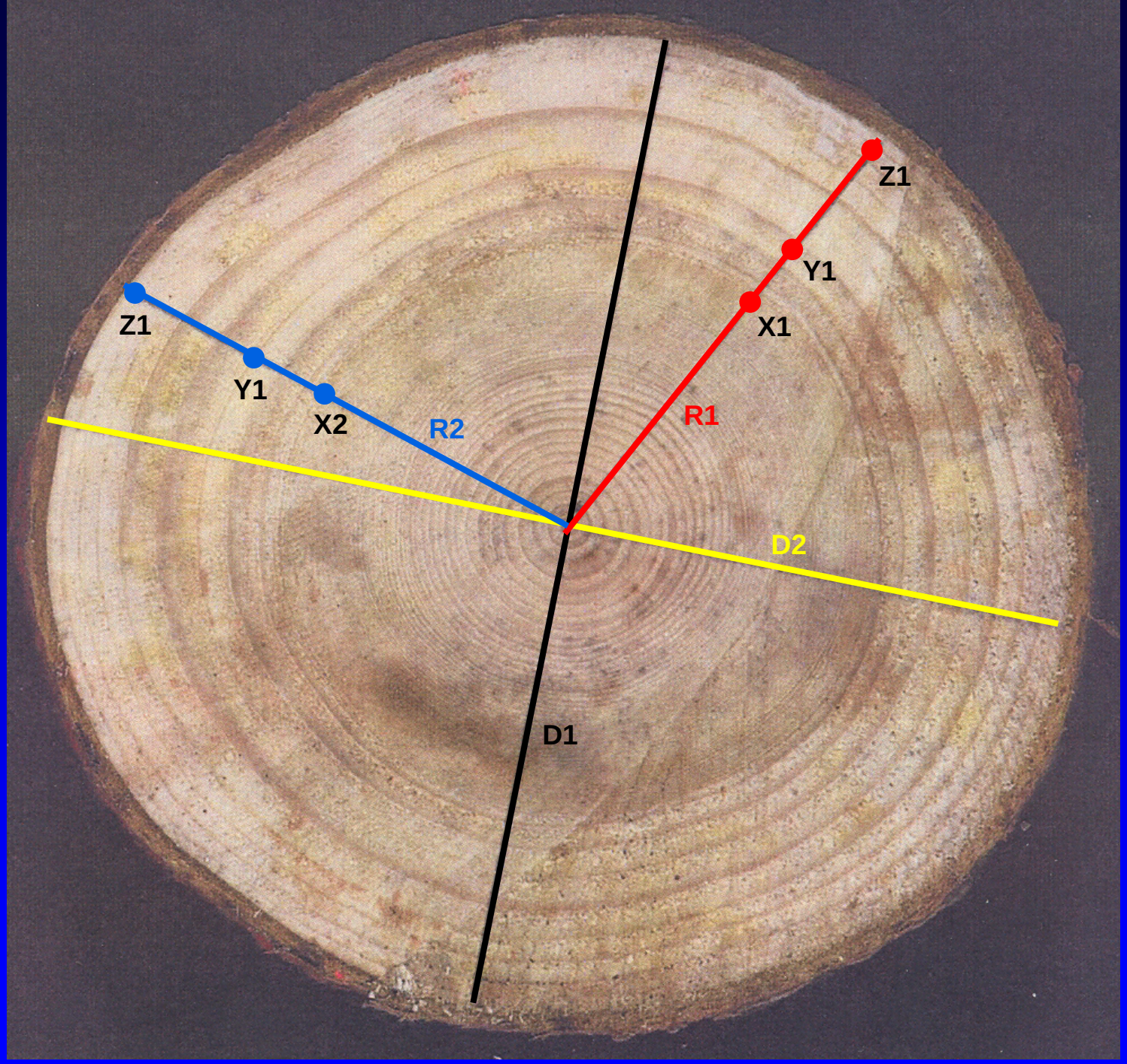
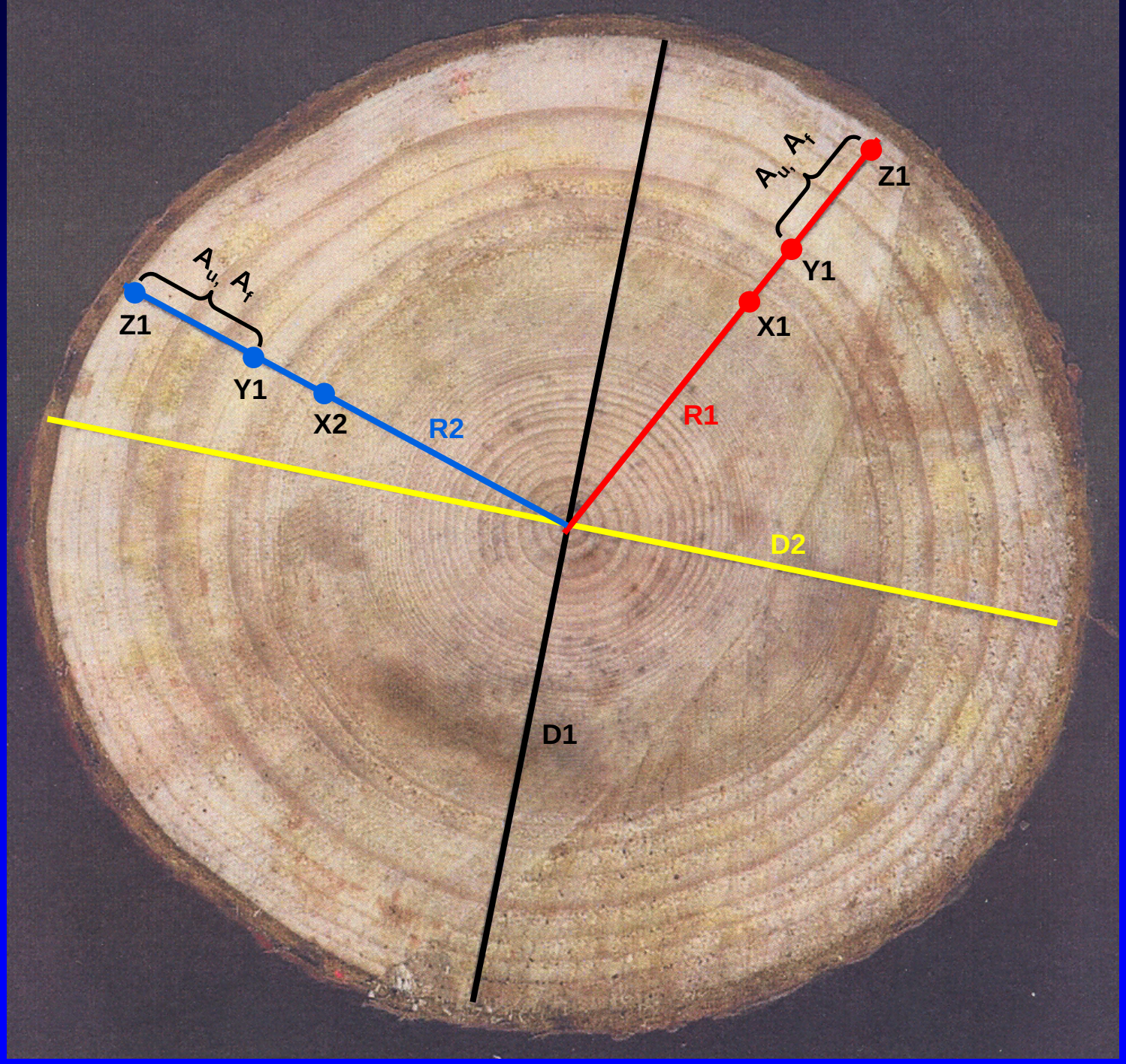
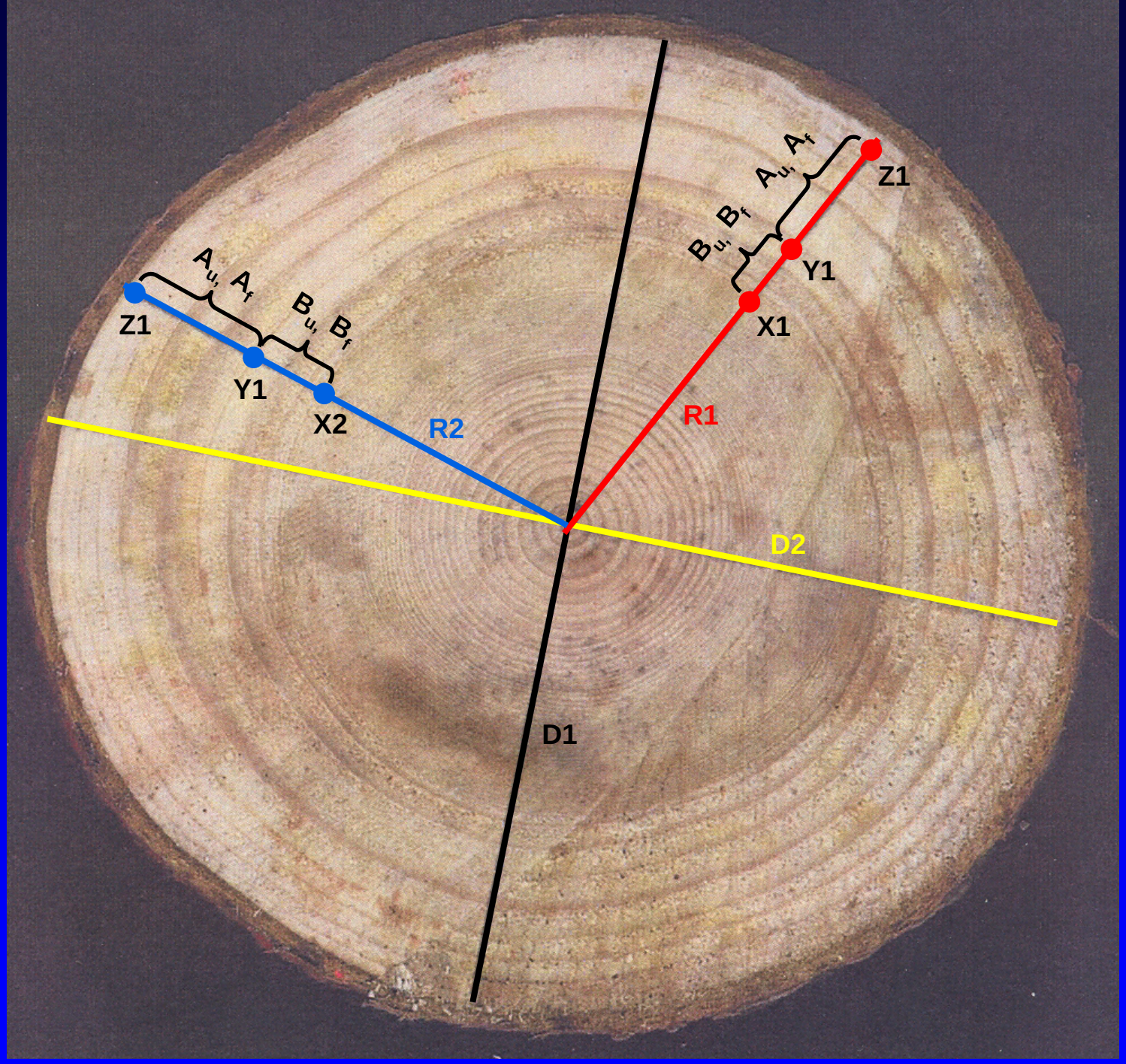
  - Distance from pith to the outer edge of the 2000 growth ring (year of fertilization), Y
  - Distance from the pith to the outer edge of the 2007 growth ring, Z


Z1
Y1
X2
R2
Z1
Y1
X1
R1
D2
D1


Z1
A_u
A_f
Y1
X2
R2
Z1
A_u
A_f
Y1
X1
R1
D2
D1


Z1
A_u, A_f
B_u, B_f
Y1
X2
R2
Z1
A_u, A_f
B_u, B_f
Y1
X1
R1
D2
D1

Pre- and post-fertilization radial growth (cm) in unfertilized and fertilized stands

	B_u	B_f	A_u	A_f
Mean	0.43	0.46	0.74	1.24
CV	0.33	0.24	0.38	0.37
n†	5	3	21	56

† number of samples needed to achieve a precision of ± 0.10 cm at 90% confidence

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Blunt Fire fertilization response

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Blunt Fire fertilization response

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  $av(R_f) = 1.24\ cm - 0.82\ cm$

  $av(R_f) = 0.42\ cm$

  $av(R_f) = 51\%$

Blunt Fire fertilization response

- $I = {}_{av}(A_f/B_f) - {}_{av}(A_u/B_u)$

Blunt Fire fertilization response

- $I = av(A_f/B_f) - av(A_u/B_u)$

  $I = 2.76 - 1.76$

Blunt Fire fertilization response

- $I = av(A_f/B_f) - av(A_u/B_u)$

  $I = 2.76 - 1.76$

  $I = 1.00$

Blunt Fire fertilization response

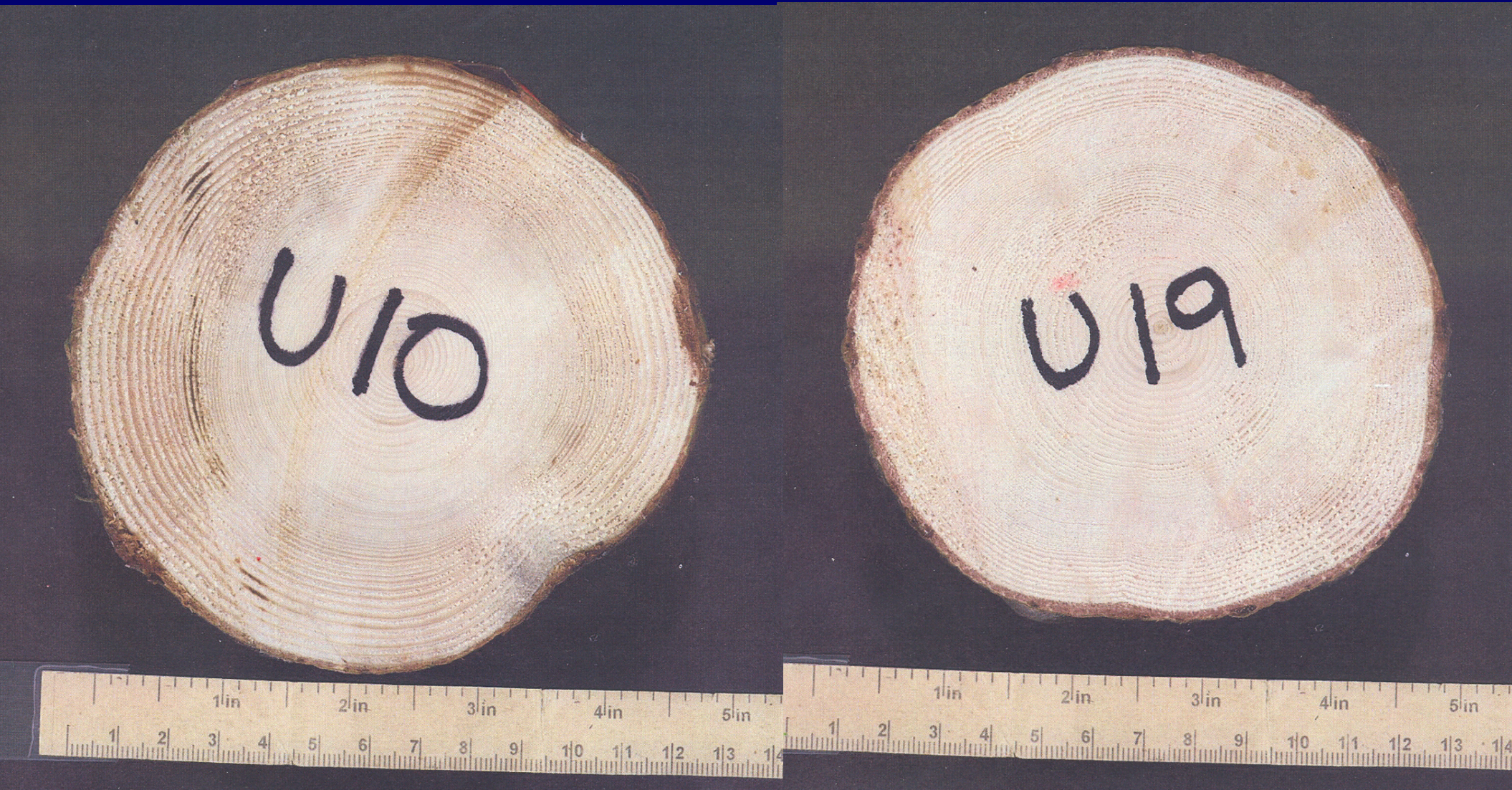
- $I = av(A_f/B_f) - av(A_u/B_u)$

  $I = 2.76 - 1.76$

  $I = 1.00$

  $I = 57\%$

Thinned (1998)



Thinned (1997) + Fertilized (2000)

Summary

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- Response potential under different site and stand conditions is still unknown
- Reliable G&Y data from a small network of well designed, area-based research field installations is needed
- In the interim, some operational fertilization of subalpine fir may be justifiable, especially in stands with a moderate component of spruce