

# Management of Douglas-fir Nutrition for the Inland Northwest

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IFTNC Annual Meeting

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University of Idaho

INTERMOUNTAIN  
FOREST TREE NUTRITION  
COOPERATIVE



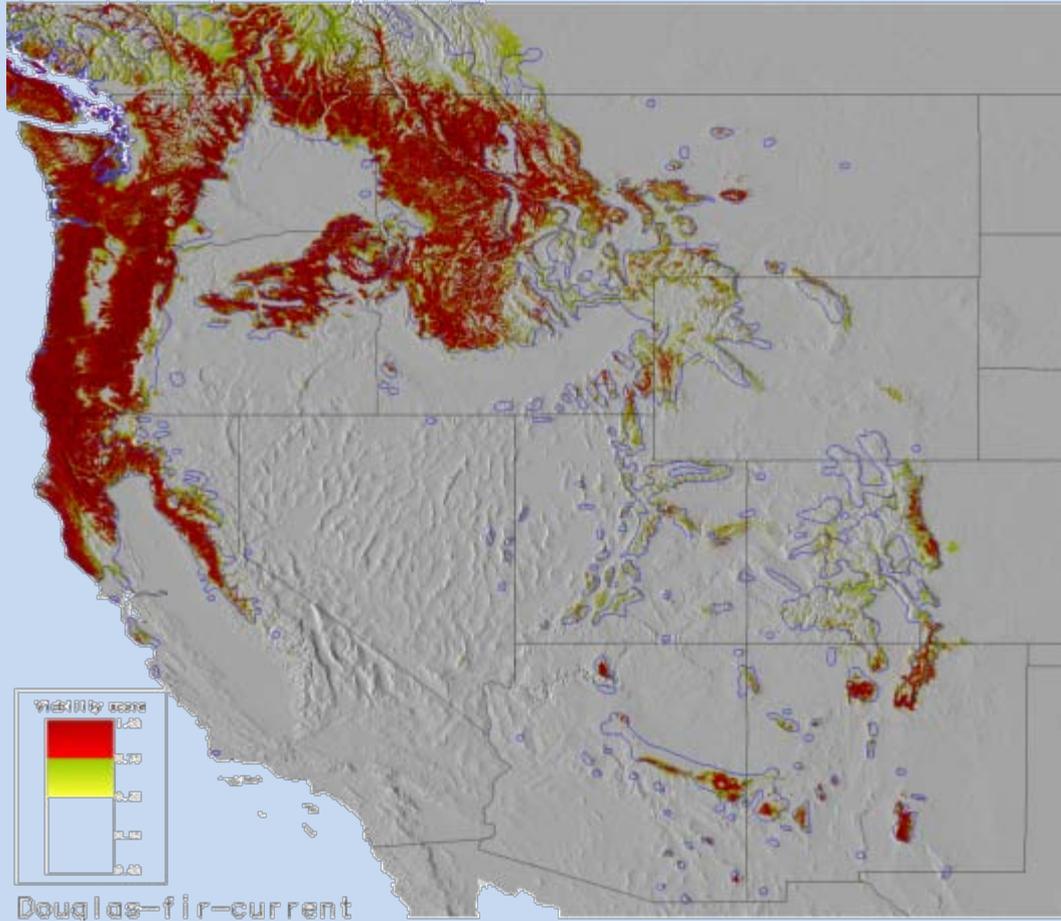
# Outline

## Douglas-fir nutrient management for INW

- Distribution and site conditions
- Nutrient characteristics
- Nutrition of mature Douglas-fir
- Nutrient imbalance
  - Potassium limitations
  - Other Inland NW nutrient limitations
- Nutrient status and soil parent material

# Douglas-fir

## *Pseudotsuga menziesii*



Interior = var. *glauca*  
Coastal = var. *menziesii*  
Northern & southern races



Hermann and Lavender 1990  
Li & Adams 1989



# Soils

- pH 5-6 preferred, tolerates 4 to >7
- Alfisols, Molisols, Spodosols, Andisols and Entisols
- Precambrian metaseds  
Miocene basalt flows  
Pleistocene glacial deposits  
Holocene loess or ash



# Site Index

- 50-yr Site index 40-90 feet
- Increases with elevation (veg series)
- Genetic interaction:
  - Lower elevation progeny grow faster
  - Growth vs. cold tolerance tradeoff

King's Site Classes		Coastal	Interior
I	>160	XX	
II	140-160	XX	
III	120-135	XX	
IV	100-115	XX	X
V	70-90	XX	XX

# Douglas-fir Nutrient Characteristics

Con

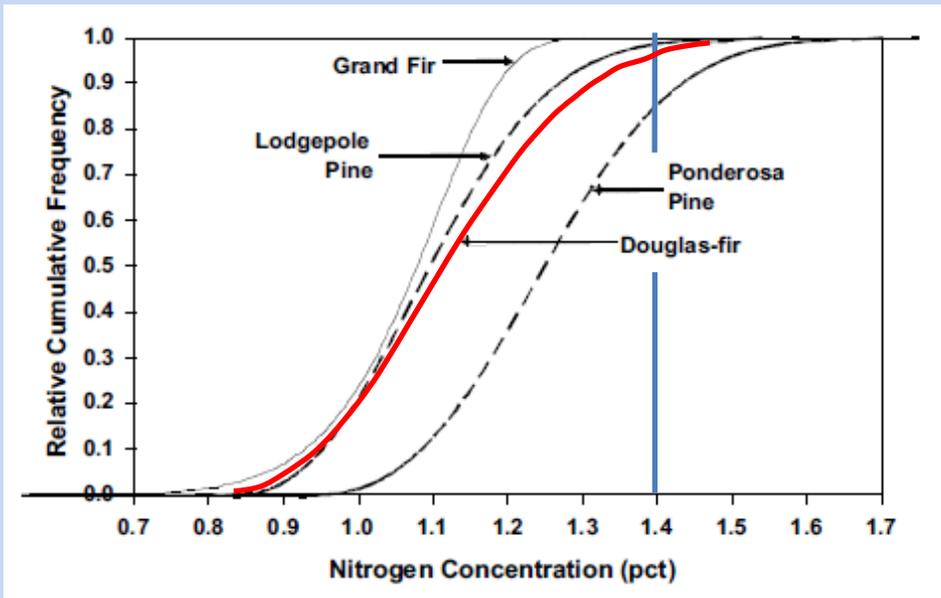
N-only

Best



# Nutrient Characteristics

- N concentration frequency distribution
- Compare to critical levels
- Most Douglas-fir stands are deficient
- N fertilizer response expected

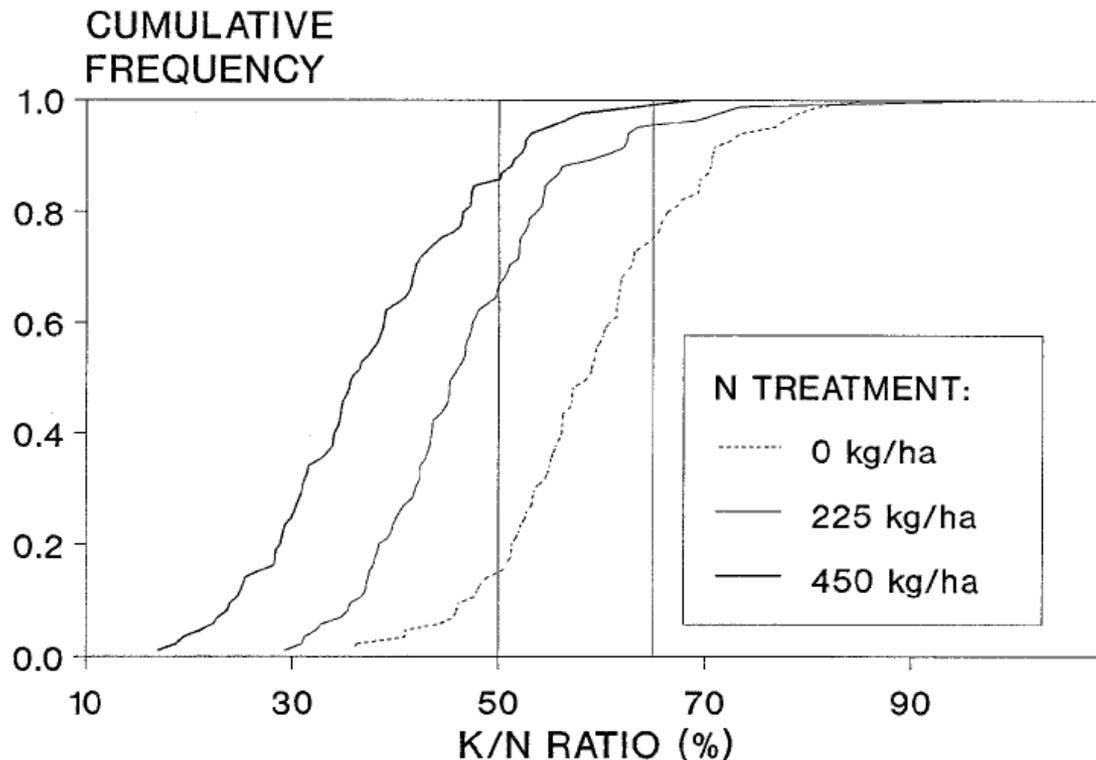


## Douglas-fir

Element	Units	Webster <sup>1</sup>
N	%	1.40
K	%	0.60
P	%	0.12
S	%	0.11
Mg	%	0.08
Ca	%	0.15
Fe	ppm	25
Mn	ppm	15
B	ppm	10
Zn	ppm	10
Cu	ppm	2

# Optimum nutrient ratios

- Nutrient ratios indicate balanced nutrition
- Relative to N = 100
- Sensitive to site and treatment



Element	Ingestad Ratios <sup>4</sup>
N	100
K	50
P	16 <sup>#</sup>
S	9 <sup>†</sup>
Mg	5
Ca	4
Fe	0.7
Mn	0.4
B	0.2
Zn	0.03
Cu	0.03

## Leaf nutrient concentrations

Percentile	N (%)	P (%)	K (%)	S (%)	Ca (%)	Mg (%)	B (ppm)	Cu (ppm)
5	0.902	<u>0.152</u>	0.519	0.042	<u>0.272</u>	<u>0.085</u>	16.7	1.83
10	0.941	0.164	0.548	0.052	0.29	0.092	18	<u>2.08</u>
20	0.995	0.179	<u>0.594</u>	0.064	0.316	0.103	<u>20</u>	2.46
30	1.038	0.191	0.635	0.073	0.337	0.114	21.7	2.78
40	1.076	0.201	0.674	0.08	0.358	0.124	23.2	3.09
50	1.113	0.21	0.715	0.087	0.378	0.135	24.8	3.39
60	1.152	0.22	0.759	0.094	0.399	0.148	26.4	3.72
70	1.193	0.23	0.81	0.102	0.423	0.162	28.3	4.08
80	1.242	0.241	0.873	<u>0.11</u>	0.453	0.181	30.6	4.53
90	<u>1.311</u>	0.257	0.968	0.122	0.495	0.21	33.8	5.18
95	<u>1.368</u>	0.269	1.051	0.131	0.531	0.235	36.6	5.74

## Leaf nutrient ratios

Percentile	P/N	K/N	S/N	Ca/N	Mg/N	B/N	Cu/N
1	7	36		<u>17.2</u>	<u>5.9</u>	0.112	0.015
5	14	45.8	3.4	20.7	7.04	0.124	0.017
10	15	<u>50.3</u>	3.47	23.2	8.07	0.143	0.02
20	<u>16.2</u>	53.8	5.17	27.3	9.3	0.186	0.024
30	17	57.1	5.76	29.4	10.53	<u>0.198</u>	0.025
40	18	60.1	6.78	31.8	11.1	0.211	0.028
50	18	63.1	6.98	33.4	12.1	0.221	<u>0.029</u>
60	20	69	7.41	36.04	12.98	0.235	0.032
70	21	73.3	<u>8.02</u>	39.5	14.4	0.251	0.038
80	22	79.8	9.45	43.49	16.6	0.272	0.043
90	24	88.79	10.52	48.4	19.2	0.299	0.055
95	27	93.6	11.21	52.3	20.8	0.34	0.063
99	33	110.1	11.23	62.4	23.3	0.371	0.075

- Critical values underlined

- Most interior Douglas-fir are deficient in N and S

- Micro nutrients may be a concern

# Outline

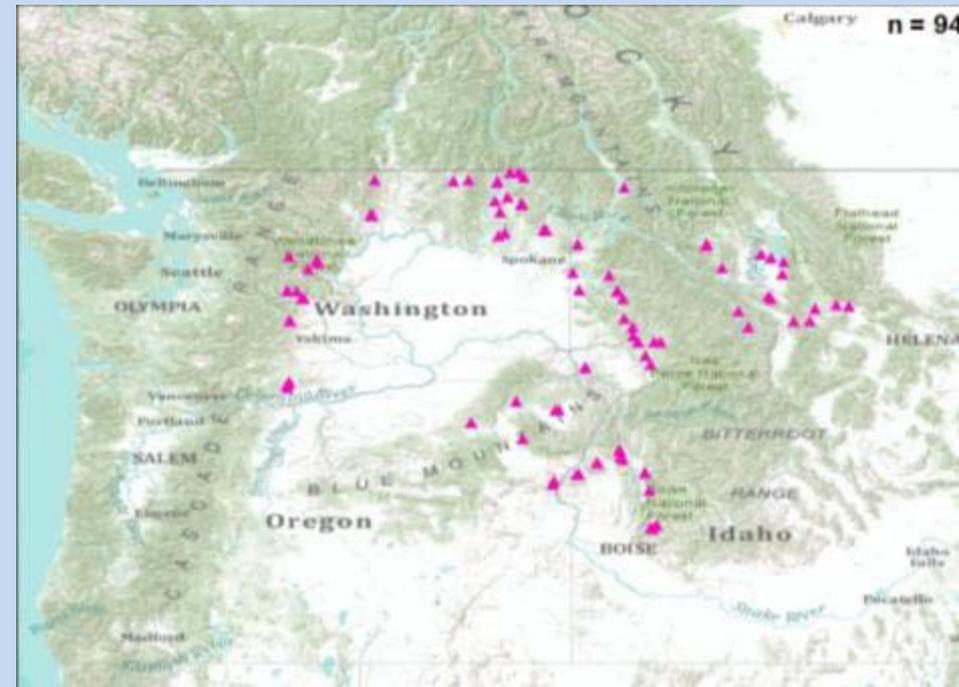
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- Distribution and site conditions
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# Douglas-fir Regional Fertilization Trials

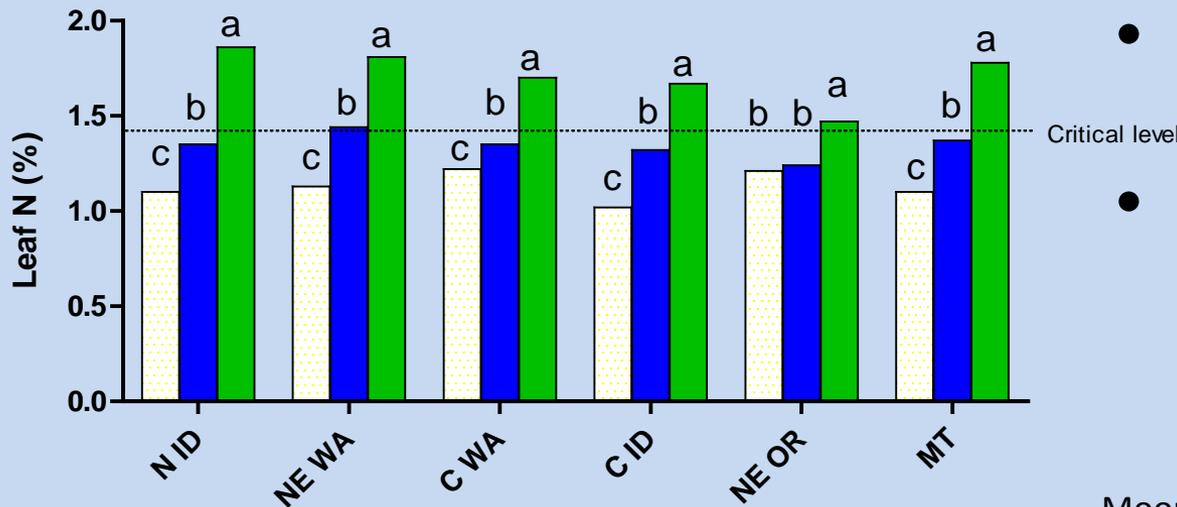
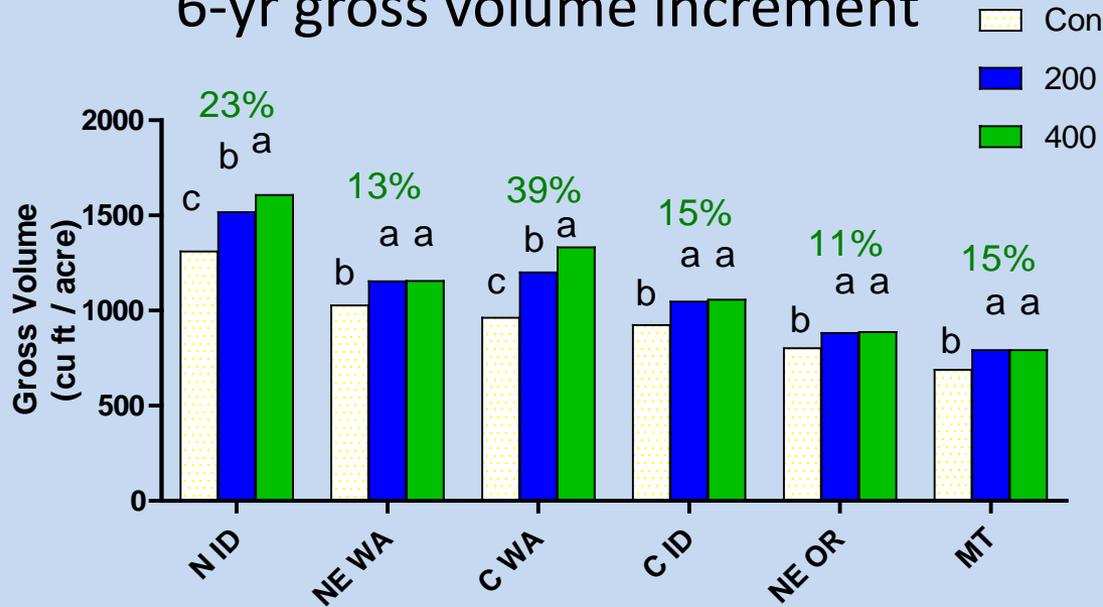
## Broad spatial and temporal extent

- 94 installations in six regions across the INW
- Tree growth and mortality monitored every 2 yrs for 10 yrs
- 2nd growth Douglas-fir
- Managed and even-aged
- 200 and 400 lbs N/acre
- Thinned or naturally well spaced



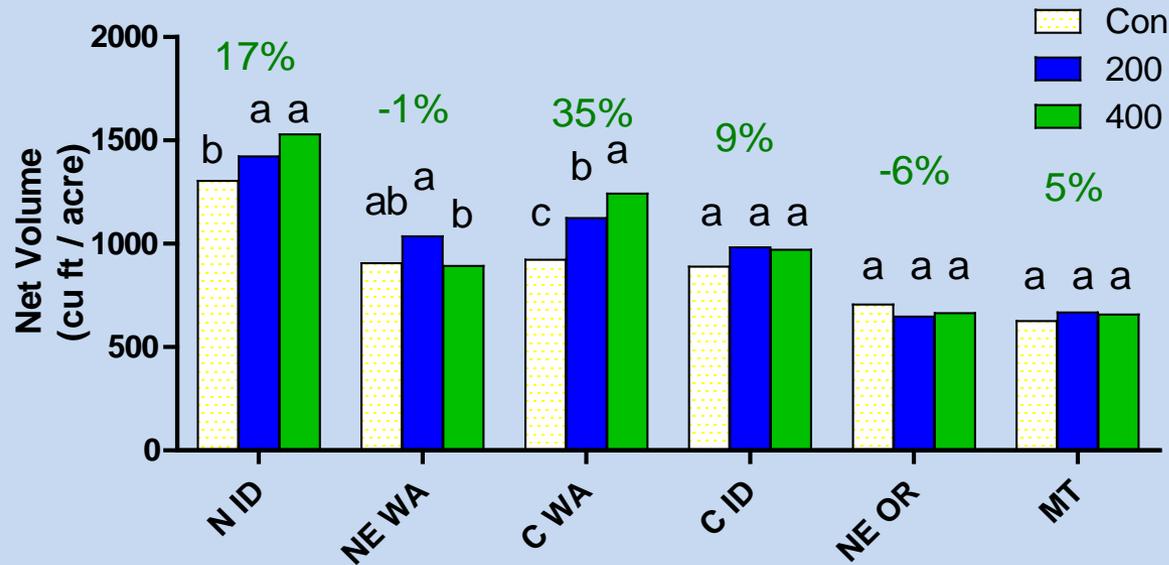
# Douglas-fir Regional Fertilization Trials

## 6-yr gross volume increment



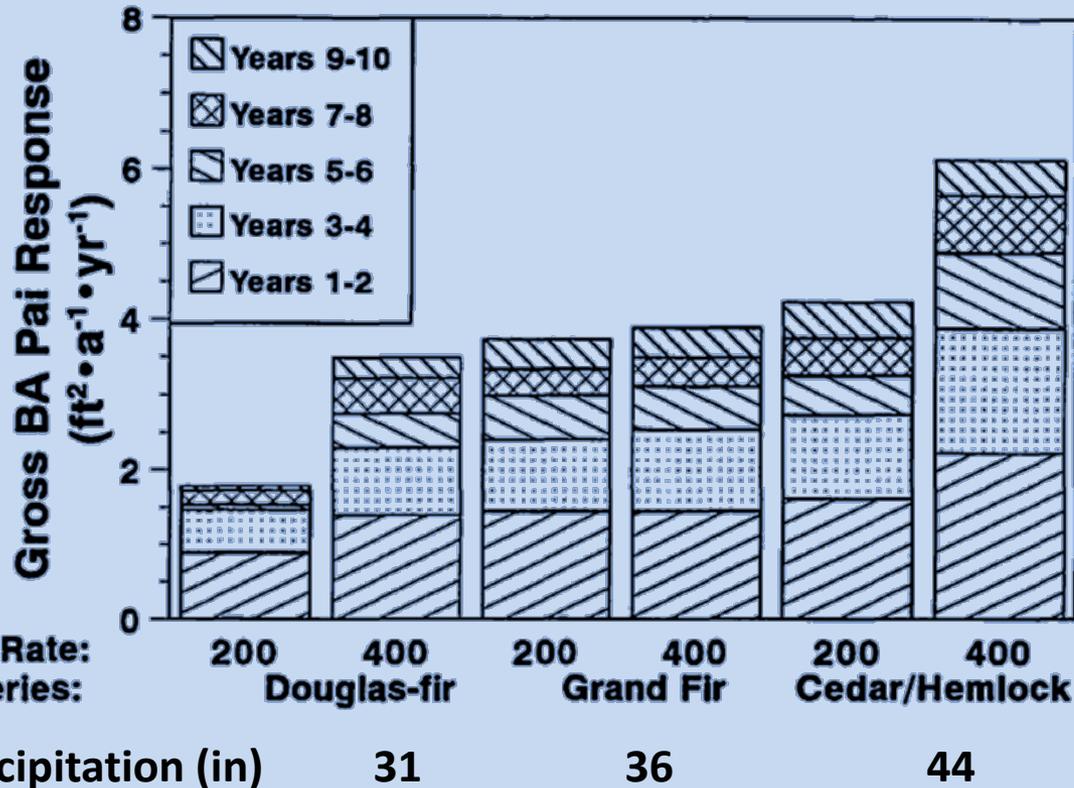
- Universal response to N
- Something else limits growth
- Low responses in low-productivity regions
- Higher rate has no effect in low-growth regions
- Higher rate increases leaf N above low rate
- Trees acquire applied N

## Douglas-fir Regional Fertilization Trials



- N fertilization increases mortality
- Lower net volume responses indicates considerable mortality
- Mortality response is lowest in regions with greatest growth response
- Moisture, other nutrients might be limiting response

# Douglas-fir Regional Fertilization Trials



- Growth response increases 60% with veg series
- Warm-dry to cool-moist
- Growth on PSME series is both N and water limited
- Little or no fertilizer response expected on dry sites

- Response decreases over time
- Results in higher volume stands
- Higher value goods and services

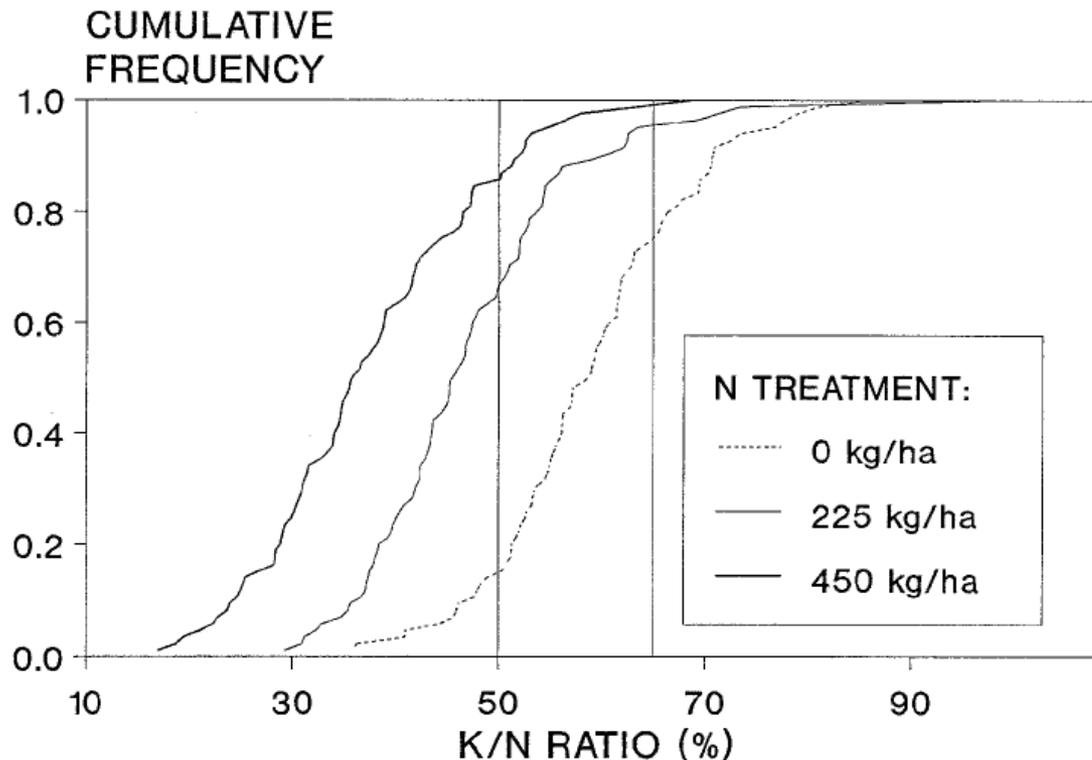
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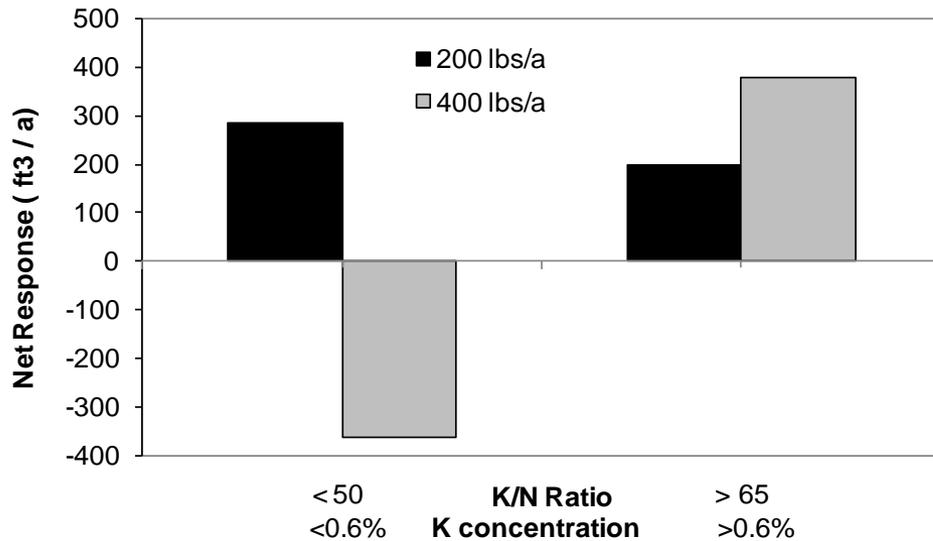
# Douglas-fir Regional Fertilization Trials

- Nutrient imbalance from N fertilization
- K/N shifts from most locations above optimum to most below



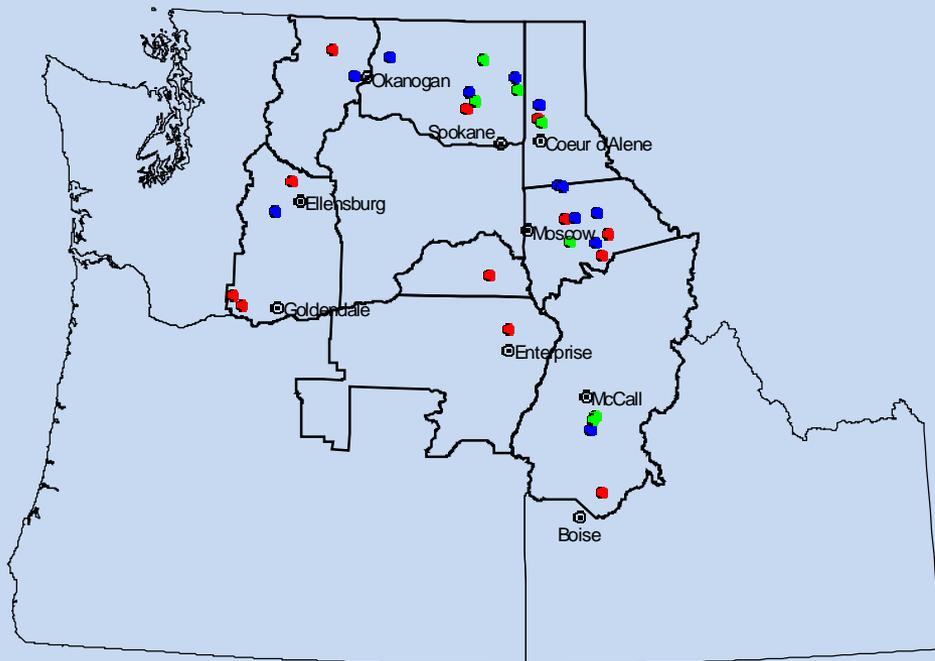
# Douglas-fir Regional Fertilization Trials

## K-dependent mortality



- Divided locations between low and high initial K status
- Initial low-K are vulnerable to mortality
- Net growth response turns negative at higher rates

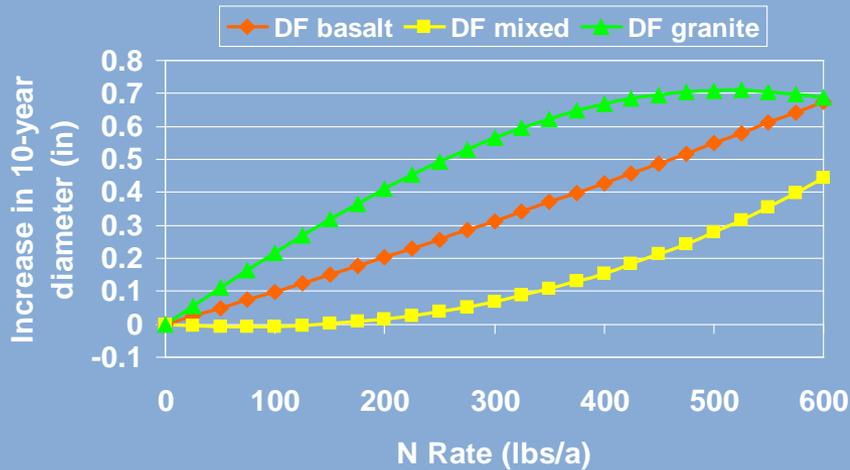
## IFTNC Forest Health / Nutrition Experimental Locations (1994-1996)



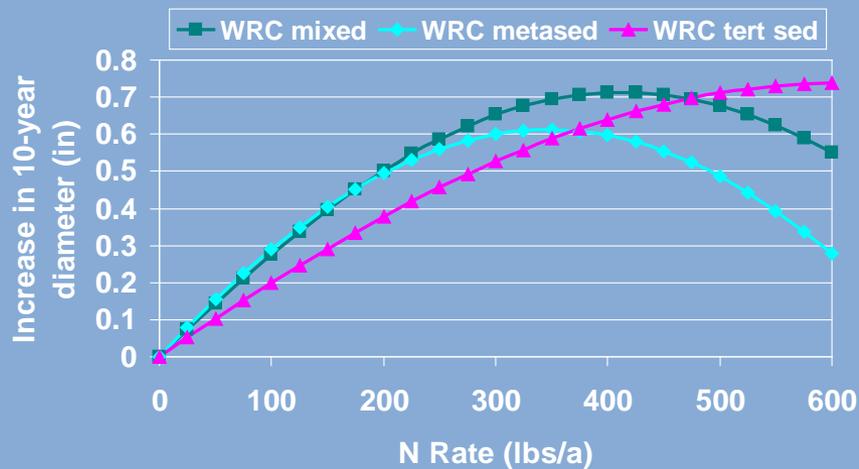
- 1994
- 1995
- 1996

- 31 sites
- Three veg series
- Four rock types
- Imbedded experiments
  - N rate study
  - Repeated fertilization study
  - \* N x K response surface study

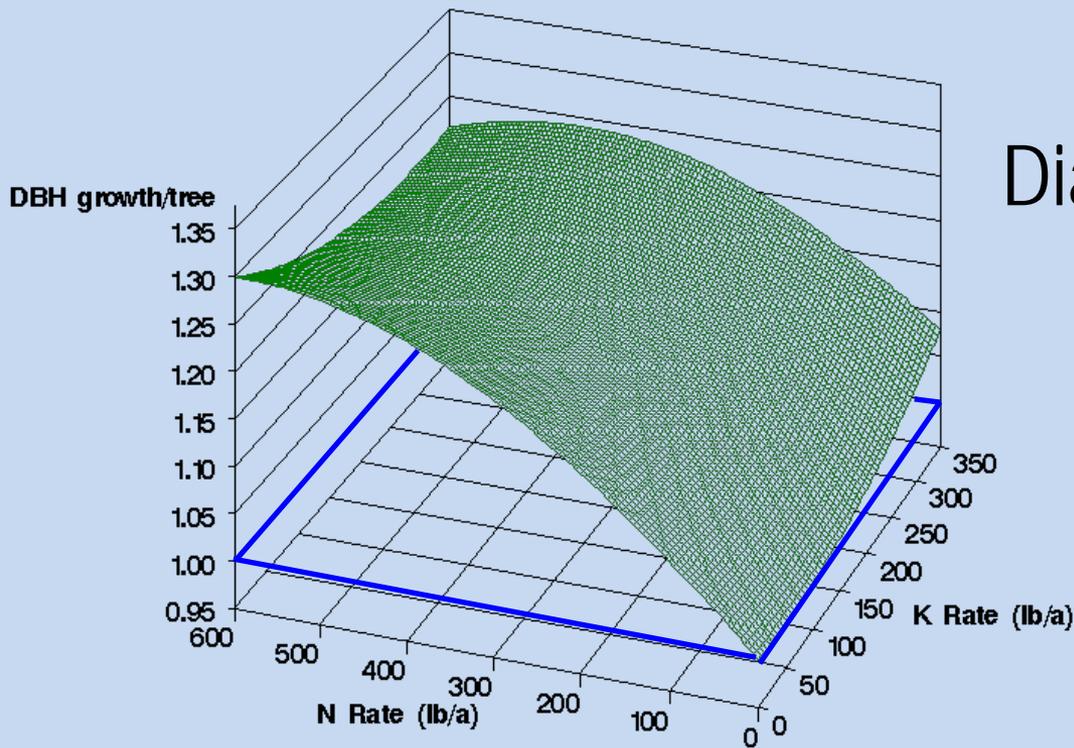
# Diameter Growth/tree



- Growth response to N fertilizer varies by rock type and vegetation series
- Widest rock type differences occur in drier vegetation series

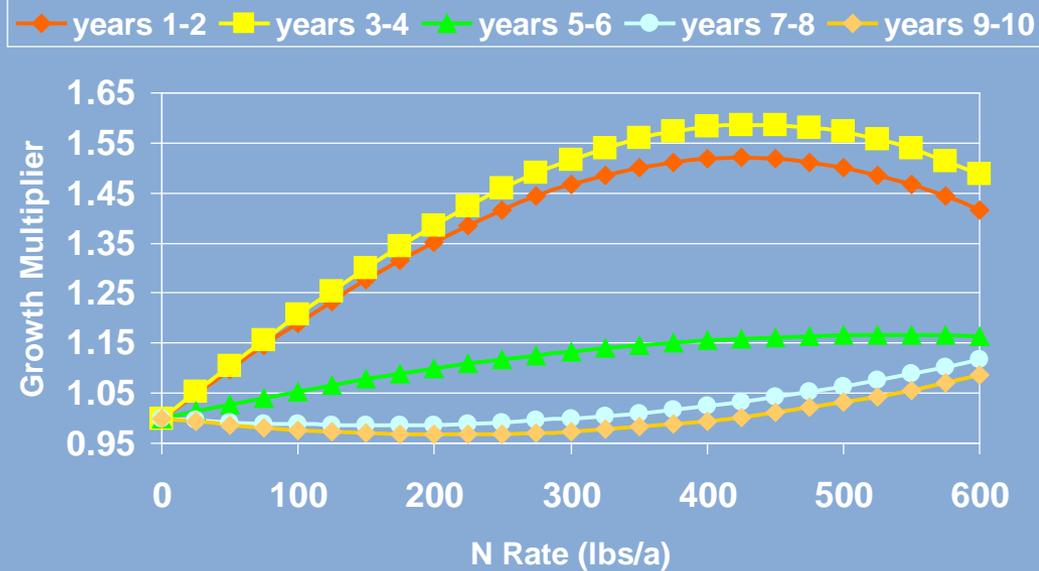


# Relative Growth: Diameter Growth/tree

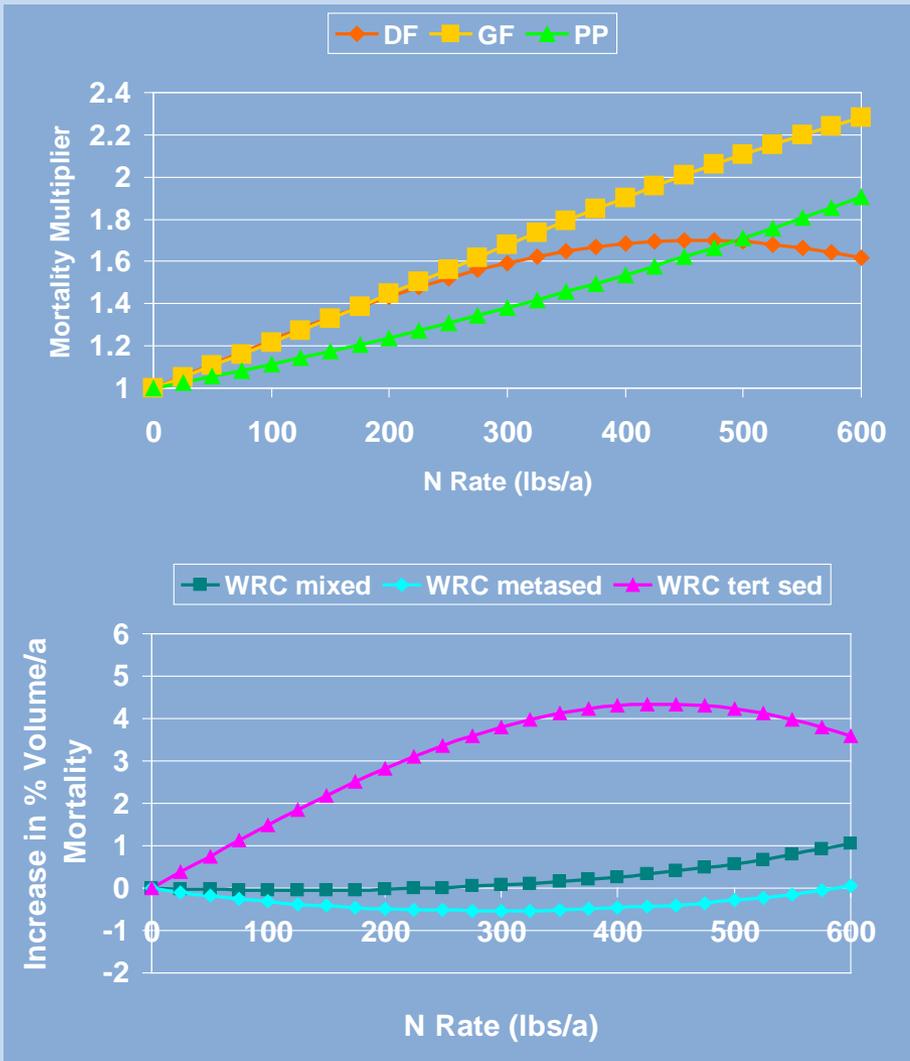


- Optimum ~400 N
- N growth response declines after 4 years

- Little growth response to K amendments
- Strong N growth response

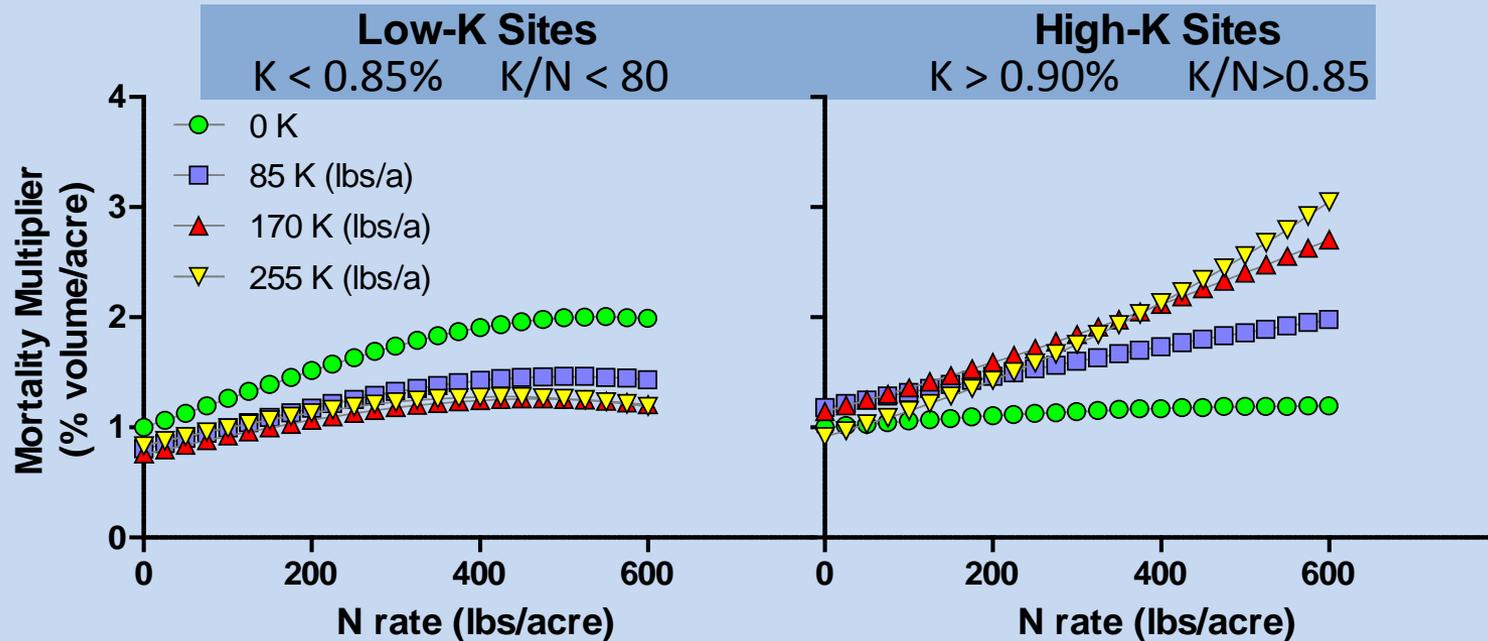


# Relative Mortality: % volume/a



- Mortality increases with rate of N application
- Douglas-fir appears to reach a maximum at ~400 lbs/ac
- Mortality response to N fertilizer varies by rock type and vegetation series
- Mortality response to K: complicated, inconsistent

# Divide sites by initial K status



- On low K sites mortality increases with N; K protects trees from death
- High-K: Mortality does not increase with N; K increases vulnerability
- Understanding initial K condition is critical to management

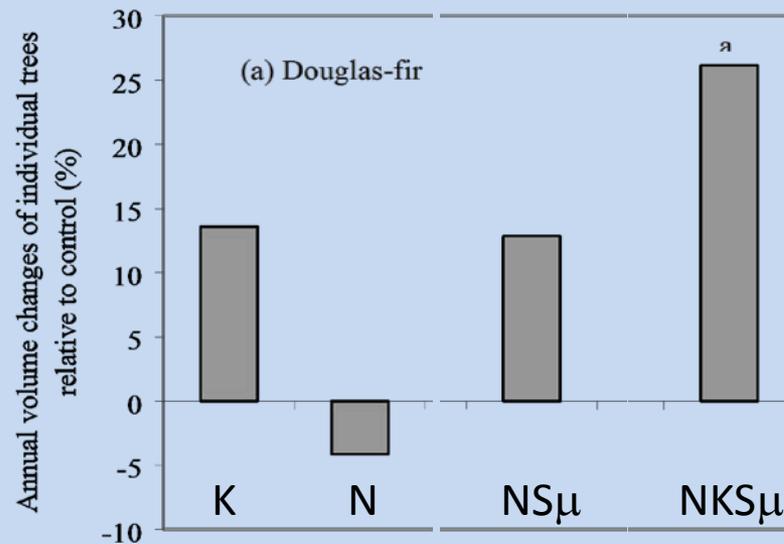
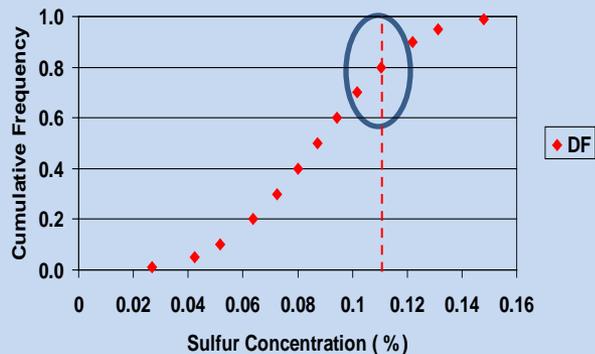
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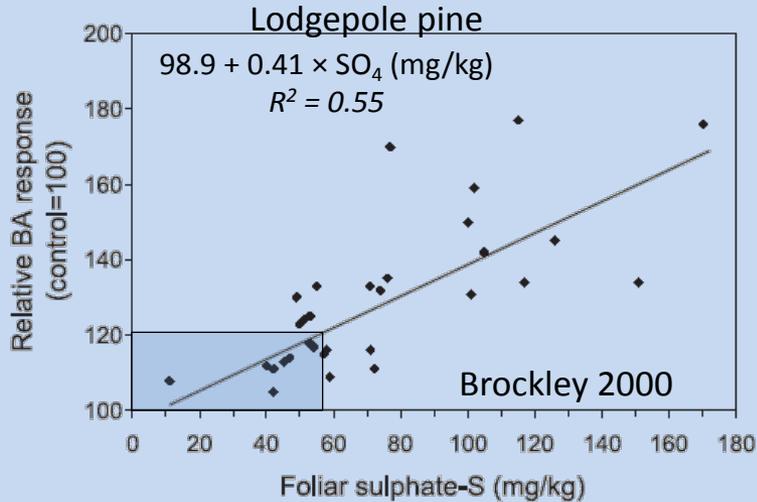
# Sulfur is regionally deficient

- Most locations are deficient
- Responses to S amendment are apparent
- Sulfur is required for proteins
- S exists in proportion to N





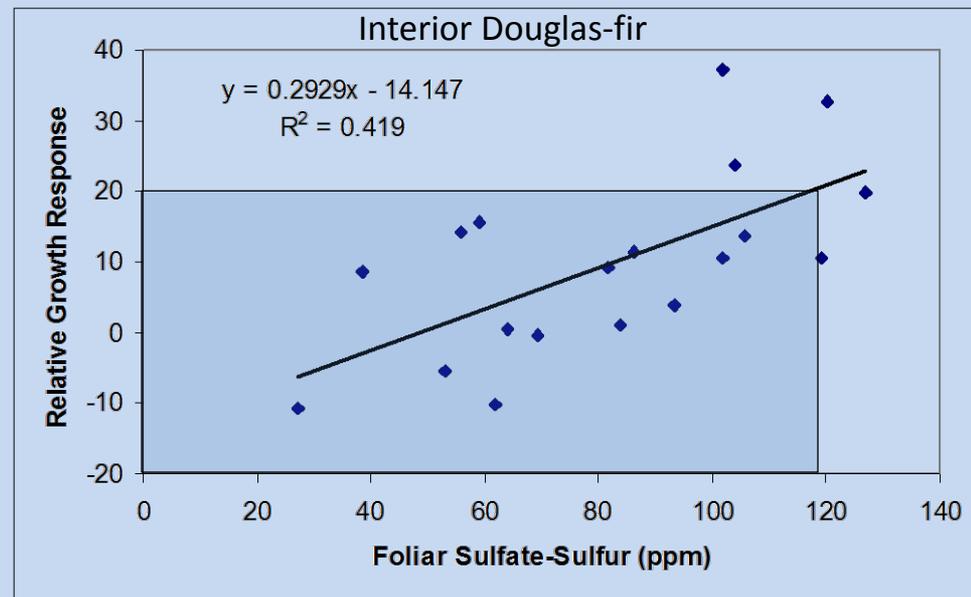
Sulfate levels corresponding to a 20 % growth response to N application is considered to be the critical level.



Box indicates 20% growth response  
 Which can be used as threshold value

Brockley	60 mg/kg
Schmalz	120 mg/kg
Turner	400 mg/kg

Schmalz and Coleman (in press).



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# Northern Idaho Belt strata

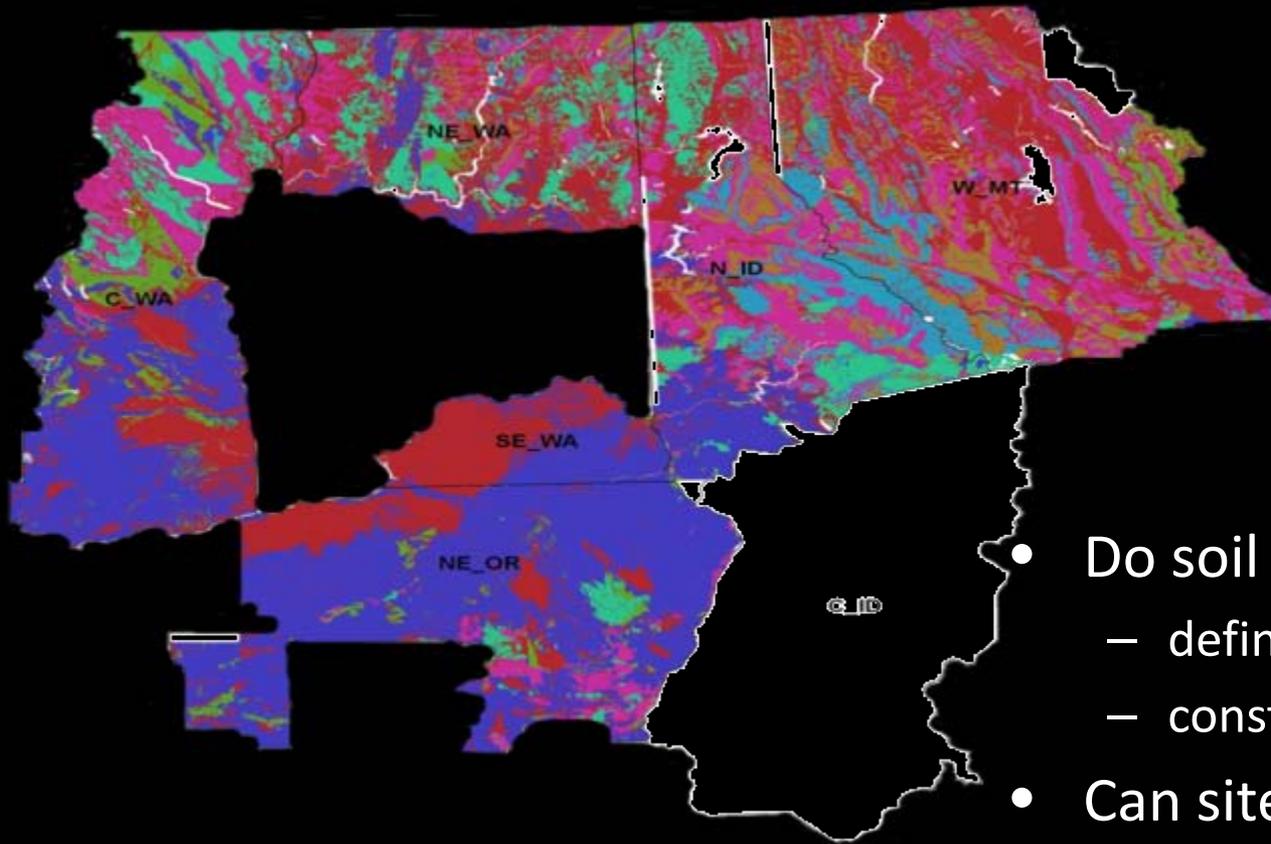
Trees grow on the argillite-siltite rock layers, but not quartzite rock



argillite-siltite

Photo by Reed Lewis

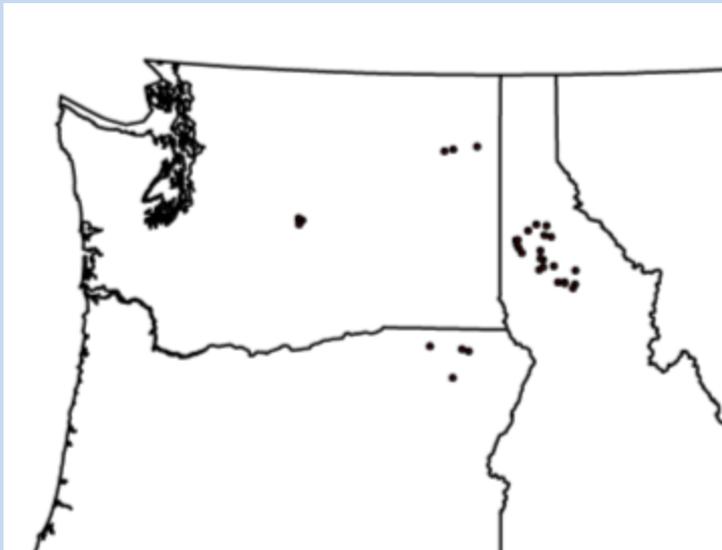
# Nutrient status and soil parent material



- Do soil parent materials
  - define nutrient availability?
  - constrain management options?
- Can site classifications define silvicultural prescriptions?

# Screening trials help to define site-types

- Efficient study design
- Deployed at numerous locations
- Site-type definitions for each location
- Reliable productivity information
- Relatively short-term experiments



# Categories define nutrient availability and management options

N-Only

Multinutrient

Unresponsive

Spatial layers for response categories are being developed in combination with climatic limitations

# Summary

## Douglas-fir nutrient management

- Region-wide N limitations
- Growth responds to fertilization by up to 40%
  - Response lasts 6-8 yrs
  - Results in enhanced stand volume
- Some sites don't respond
- Some sites respond negatively to N-fertilizer
- Other limitations create imbalance: K, S
- Parent material has important controls
- Use nutrient condition in site assessment

# Management Conclusions

- Recognizing nutrient limitations and imbalance is critical for management decisions
  - Which sites are vulnerable to degradation by slash removal?
  - Which sites are responsive to N fertilization?
  - Where will fertilization induce mortality and how to protect the stand?
- Forest managers requires tool to characterize sites
  - Geology management guidelines
  - Soil disturbance risk rating system

