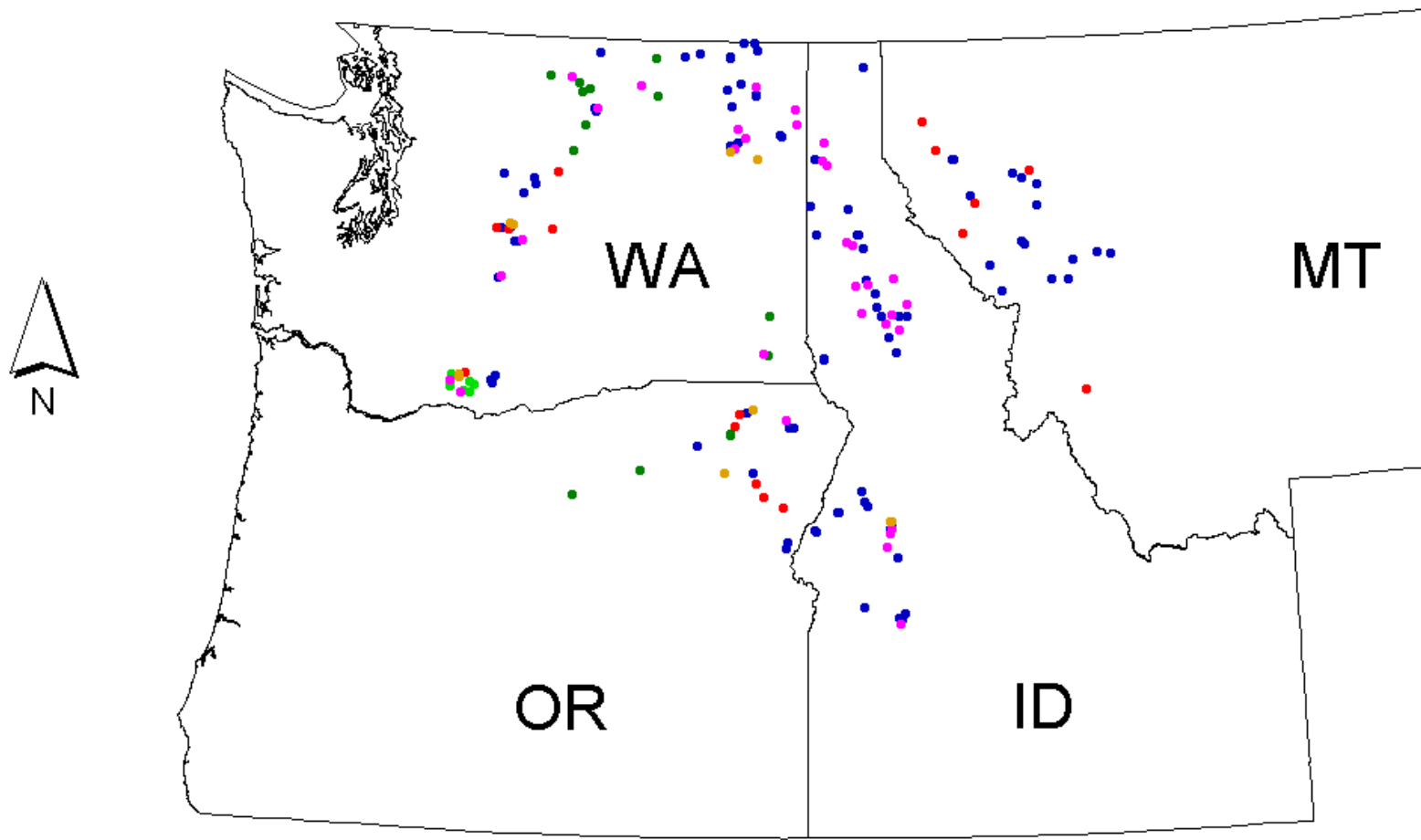




Management of Ponderosa Pine Nutrition Through Fertilization

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- Douglas-fir
- Ponderosa Pine
- Mixed Conifer
- Klickitat Add-on
- Forest Health
- Seedling Establishment

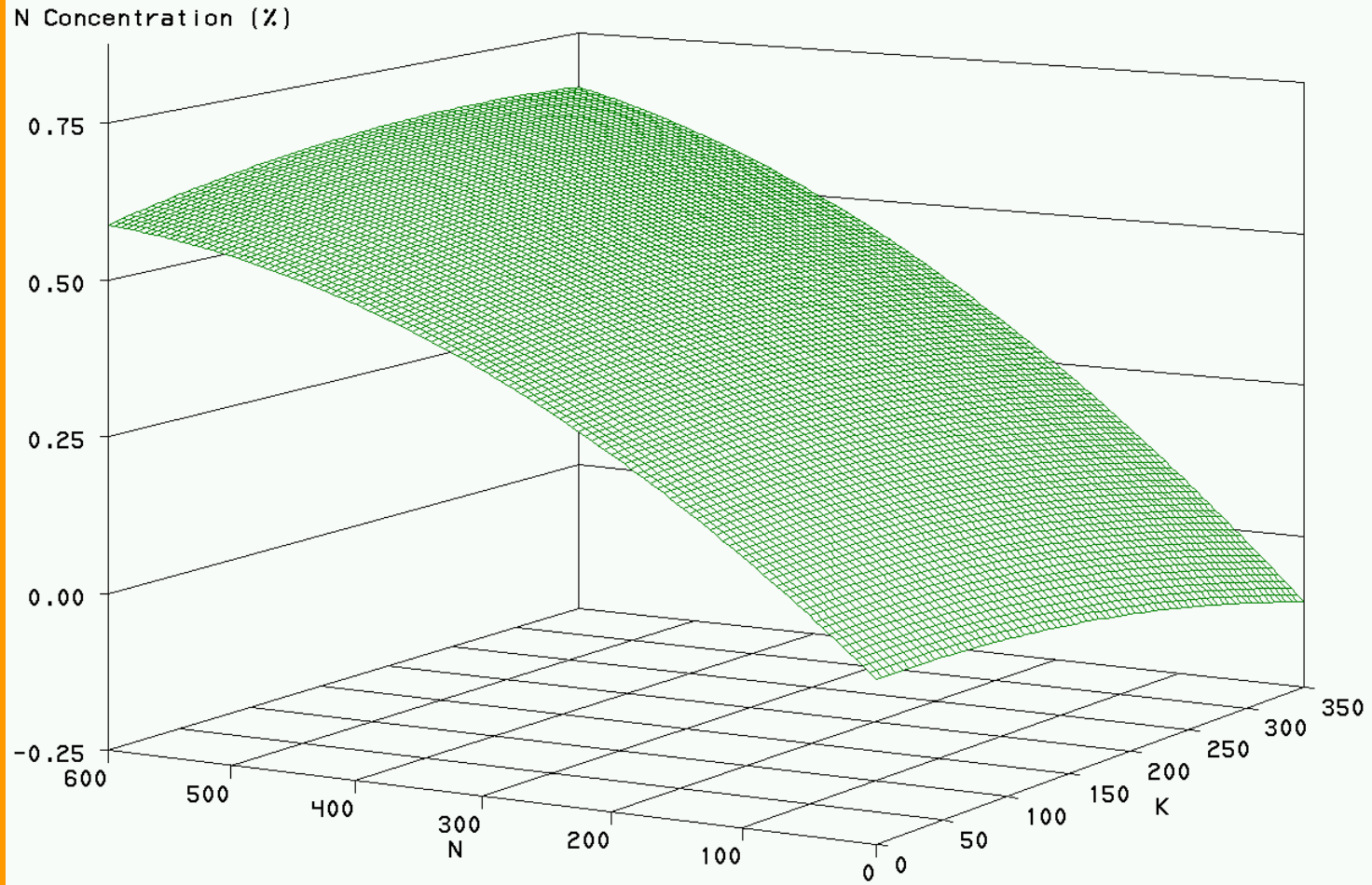
Intermountain Forest Tree Nutrition Cooperative
Research Sites 1980 - 2003

Nitrogen and Potassium

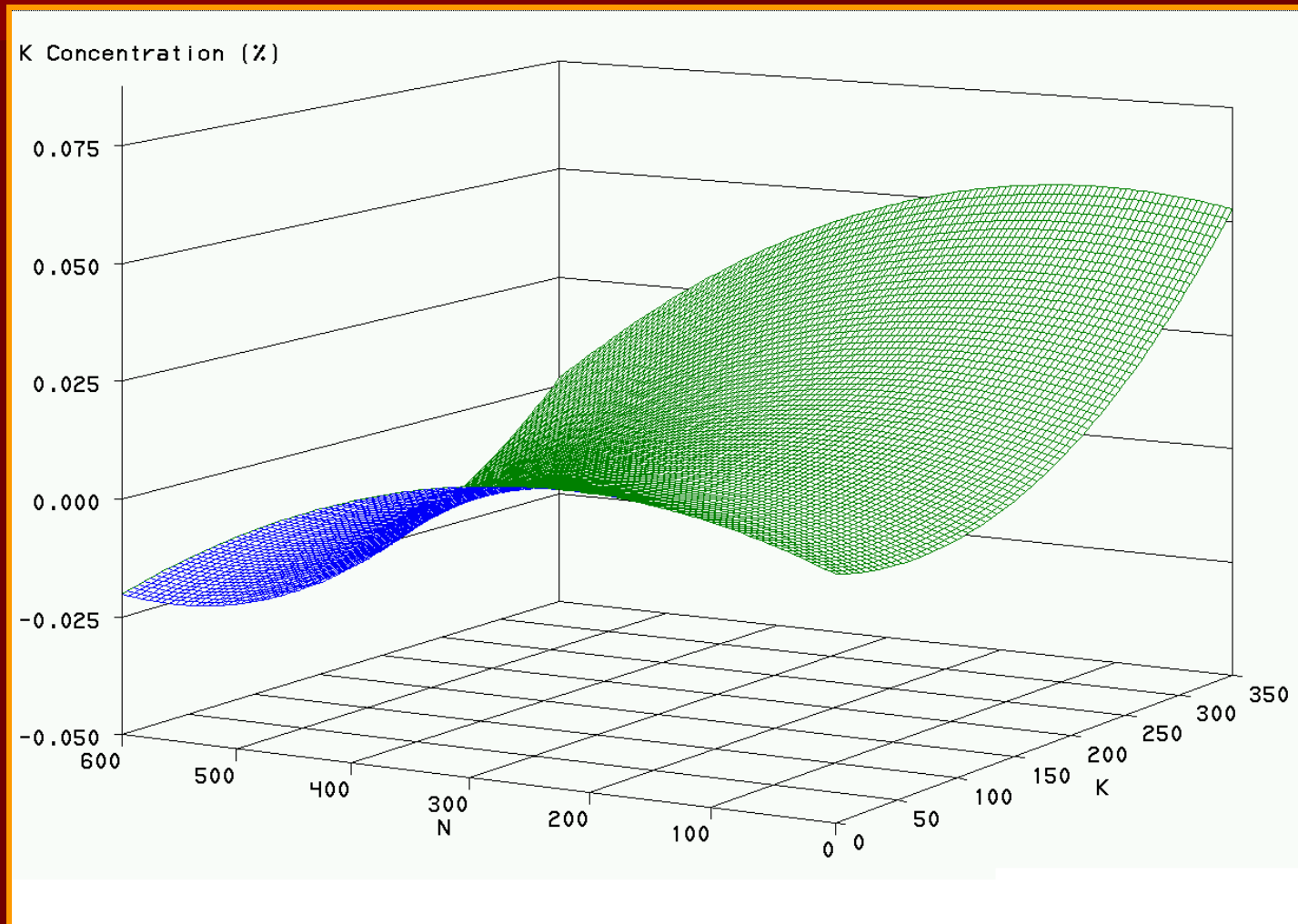
- OR/WA Ponderosa Pine Trials (1985 - N)
- MT Ponderosa Pine Trials (1987 – N,K)
- Umatilla/Okanogan Add-Ons (1991/1993 – N,K,S)
- Forest Health (1994-1996 – N,K,S,Multi)



Ponderosa Pine Foliage N Response: Forest Health Study



Ponderosa Pine Foliage K Response: Forest Health Study

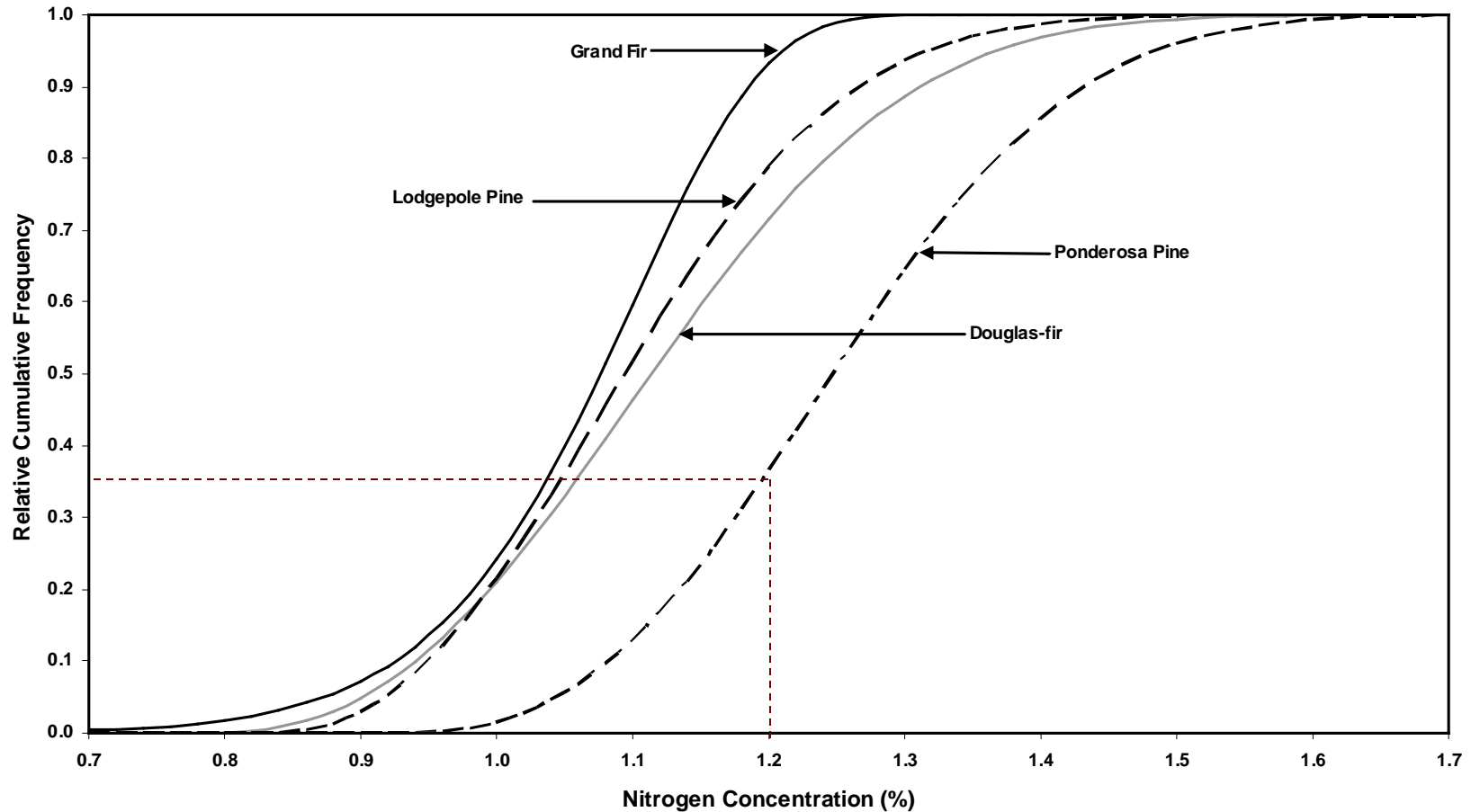


However . . .

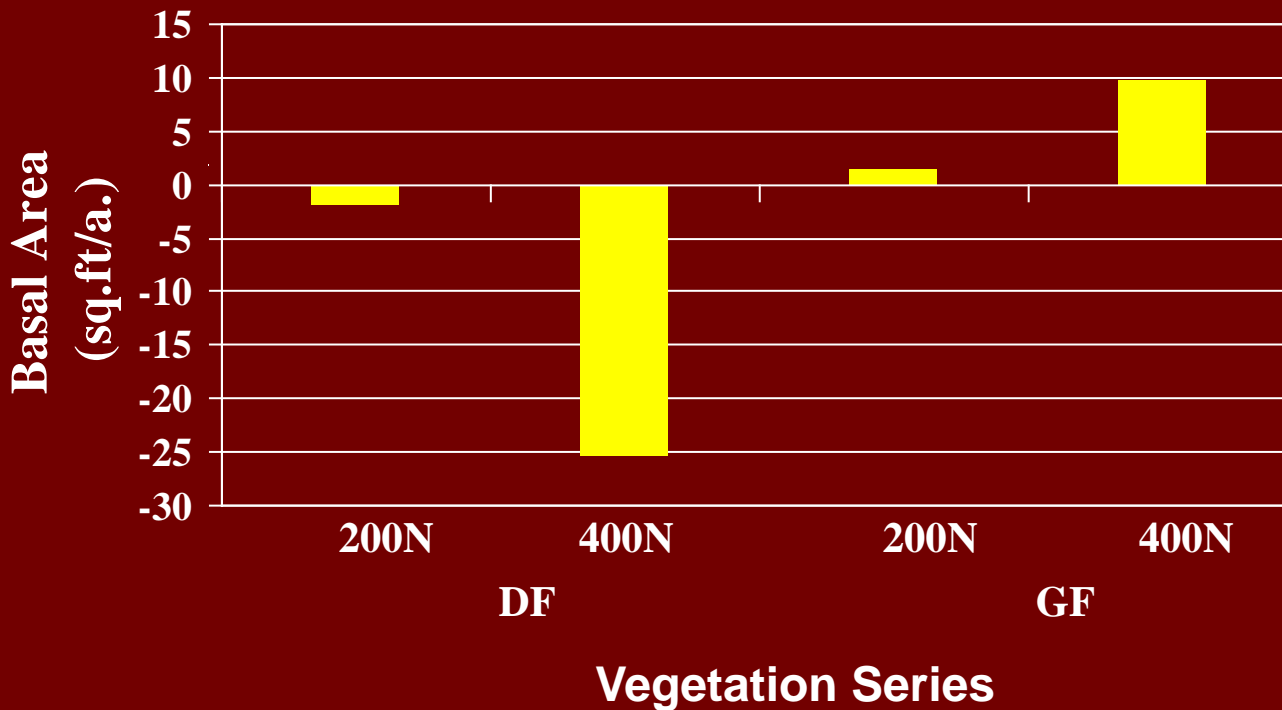
- Ponderosa pine generally has higher foliar N concentrations than other species
- Other species are more often N-deficient and show greater foliage N responses



Foliage N Concentration Distributions



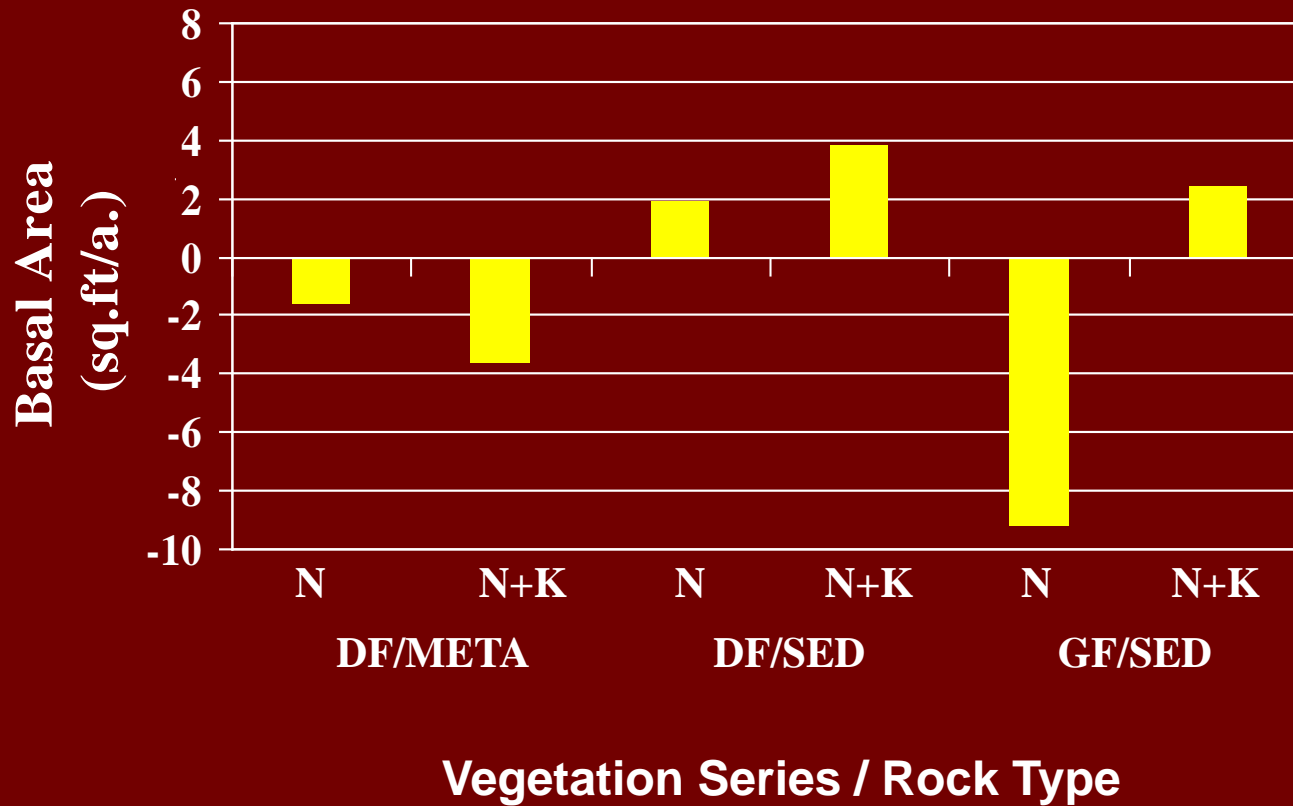
12-Year Net Basal Area Response by Vegetation Series and Treatment Ponderosa Pine Sites in N.E. Oregon and C. Washington



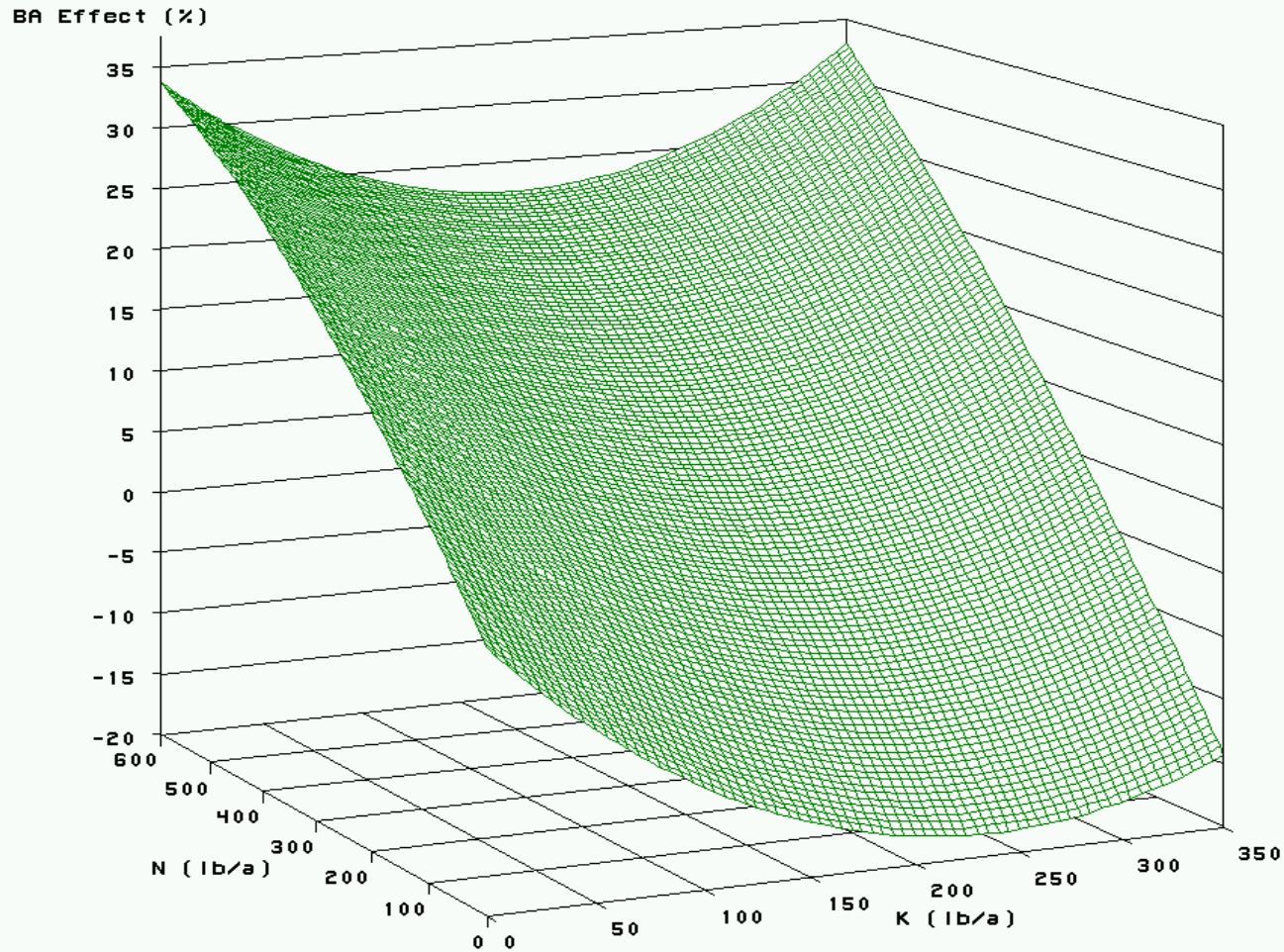
Foliage K/N Ratios

- Similar results (square death) had been found during the DF trials
- Mortality was thought to be related to foliage K status of unfertilized trees
- Foliage K/N ratios were utilized to assess site K status
- Sites with high foliage K/N (>0.65) responded well to N-only fertilization, while sites with low K/N (<0.50) showed high mortality in response to N-only fertilization
- K was incorporated into subsequent IFTNC fertilization trials
 - Montana PP
 - Okanogan Mixed Conifer
 - Forest Health

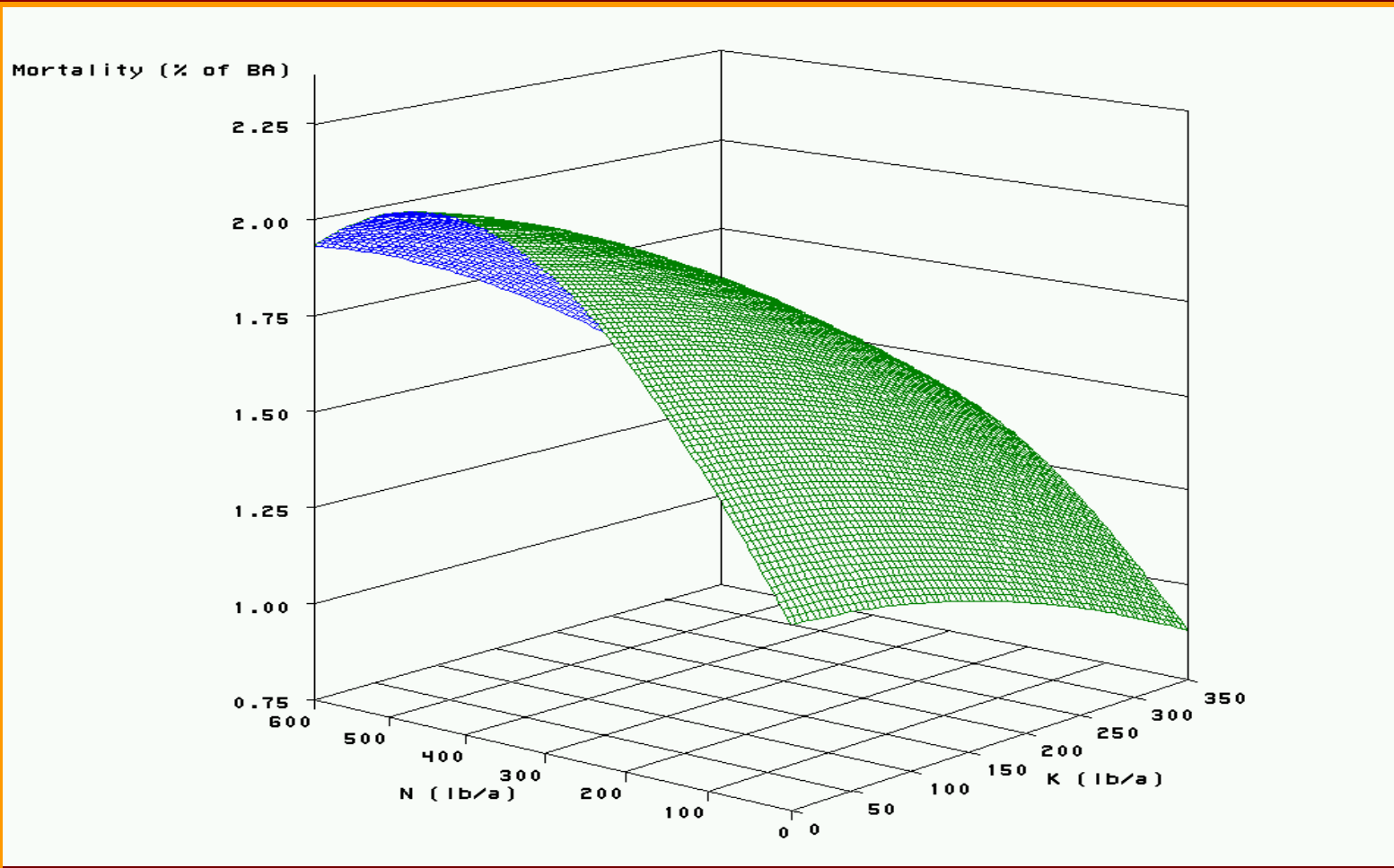
10 Year Net Basal Area Response by Vegetation Series and Rock Type Ponderosa Pine Sites in Montana



Ponderosa Pine 6-year Volume Response to N and K (FH Study)



Six-year mortality response of ponderosa pine to N and K (FH Study)



Nitrogen and Potassium Summary

■ Nitrogen

- Foliage N concentrations tend to be higher, and response to N fertilization lower for PP compared to other species
- Recommend foliage N critical level of 1.2% for PP
- N-alone can increase growth and mortality of PP, depending on rock type and vegetation series

■ Potassium

- Foliage K concentrations do not generally increase with K fertilization
- Current foliage K critical level of 0.48% is probably fine
- K does not increase PP growth rates
- K may decrease PP mortality rates
- Rock type and vegetation series impact the K effect on PP growth and mortality response to N-fertilization

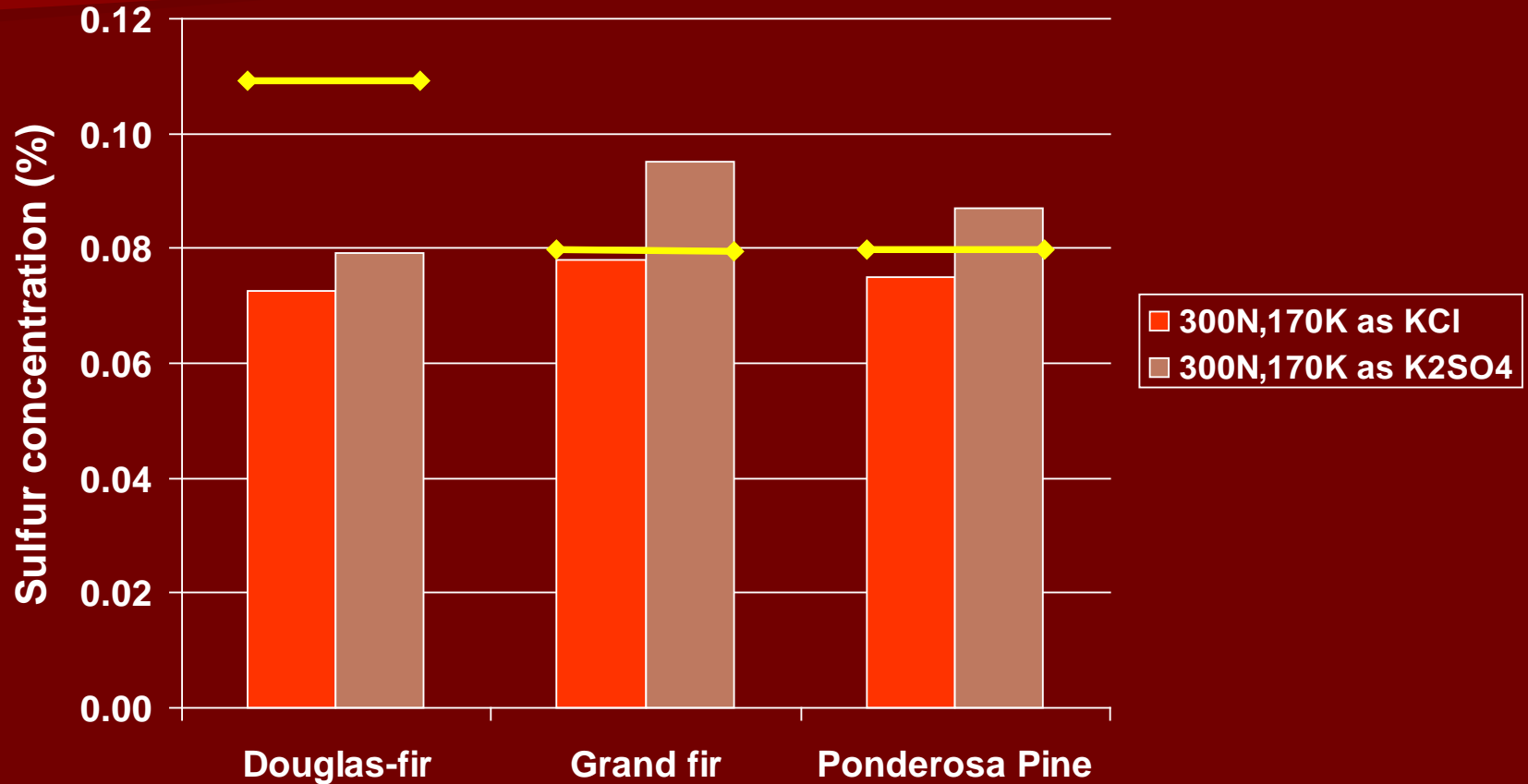


Sulfur and micronutrients

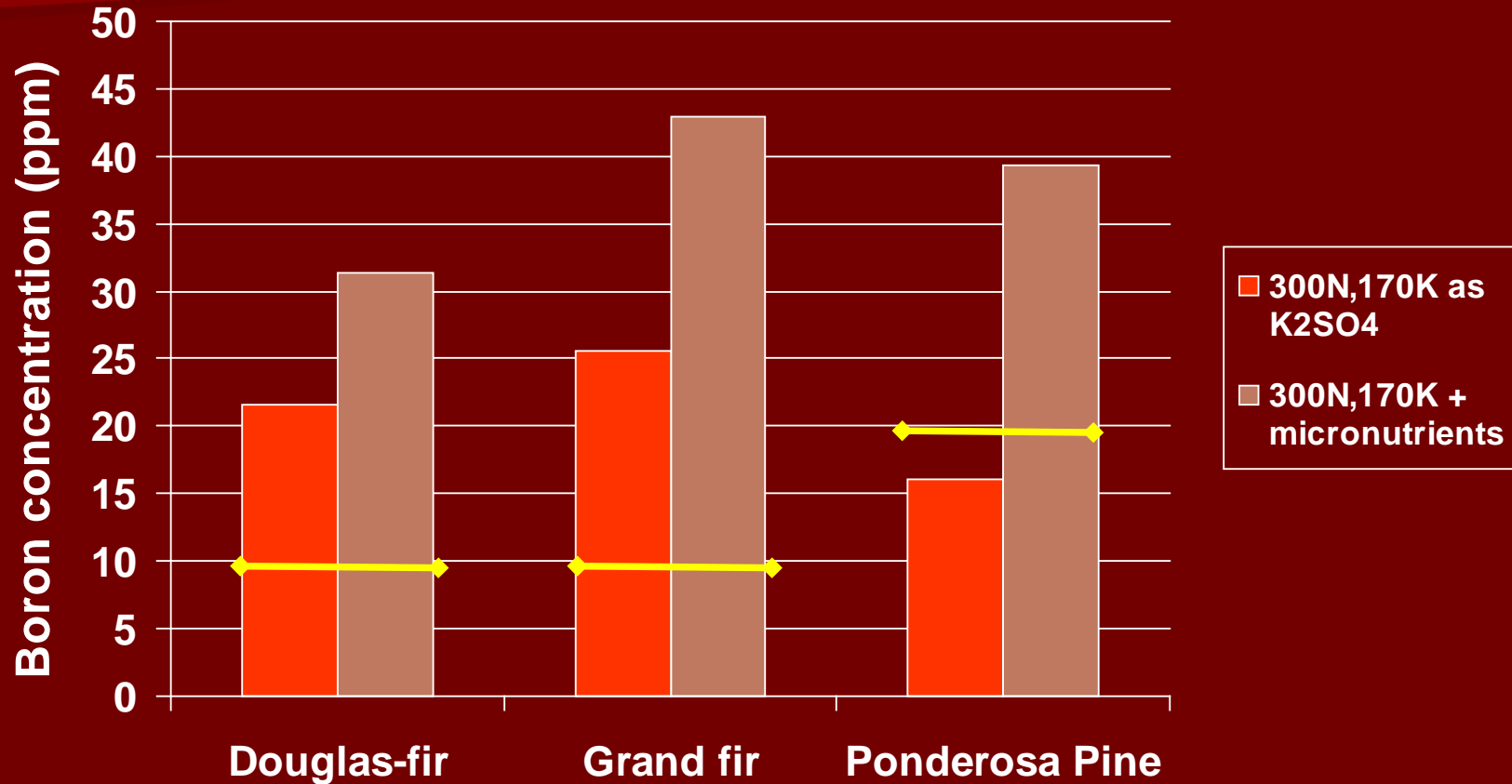
- 1991 Umatilla Mixed Conifer
- 1995-1996 Forest Health



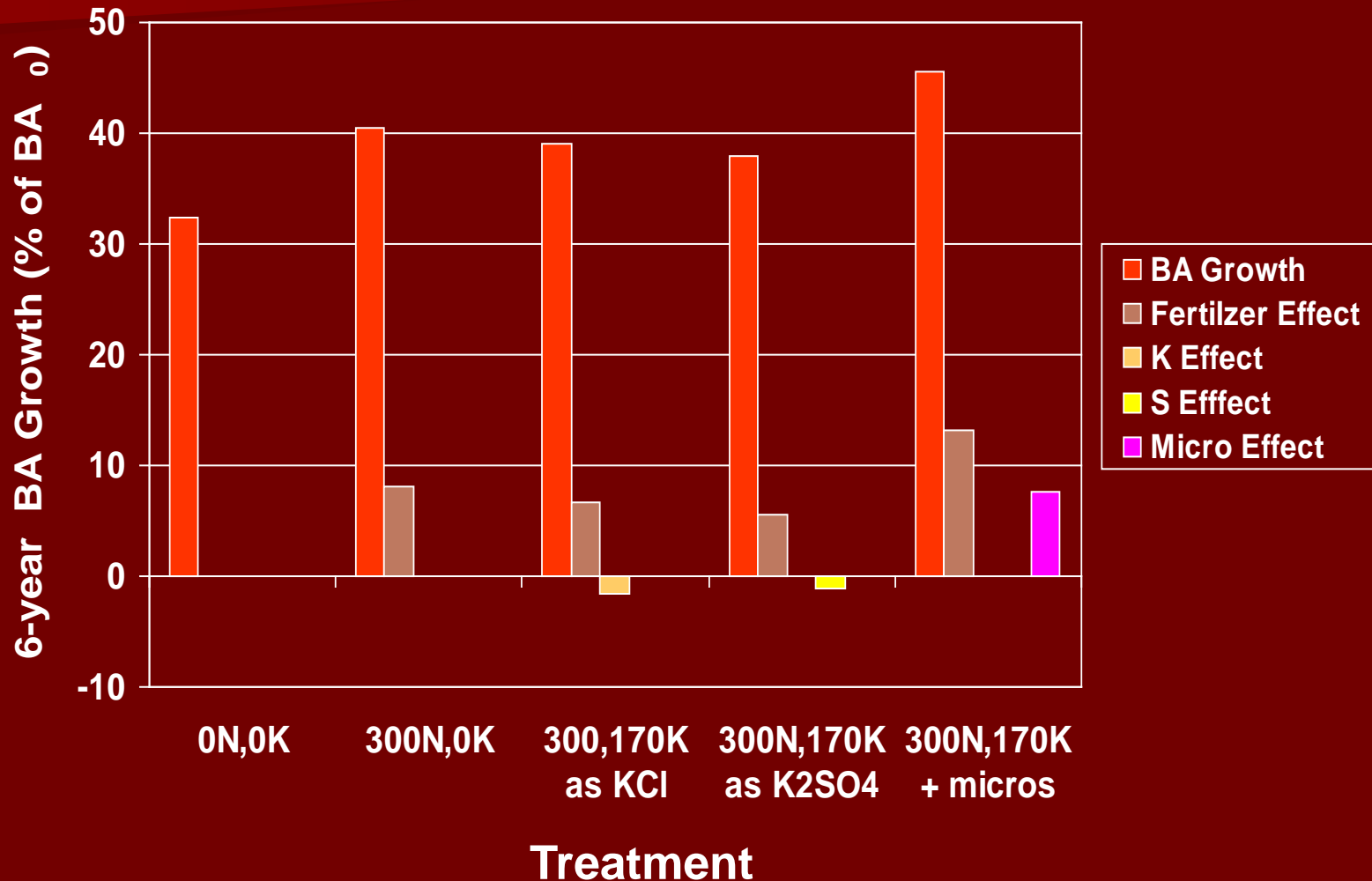
Forest Health: Effect of S fertilization on foliar S concentrations



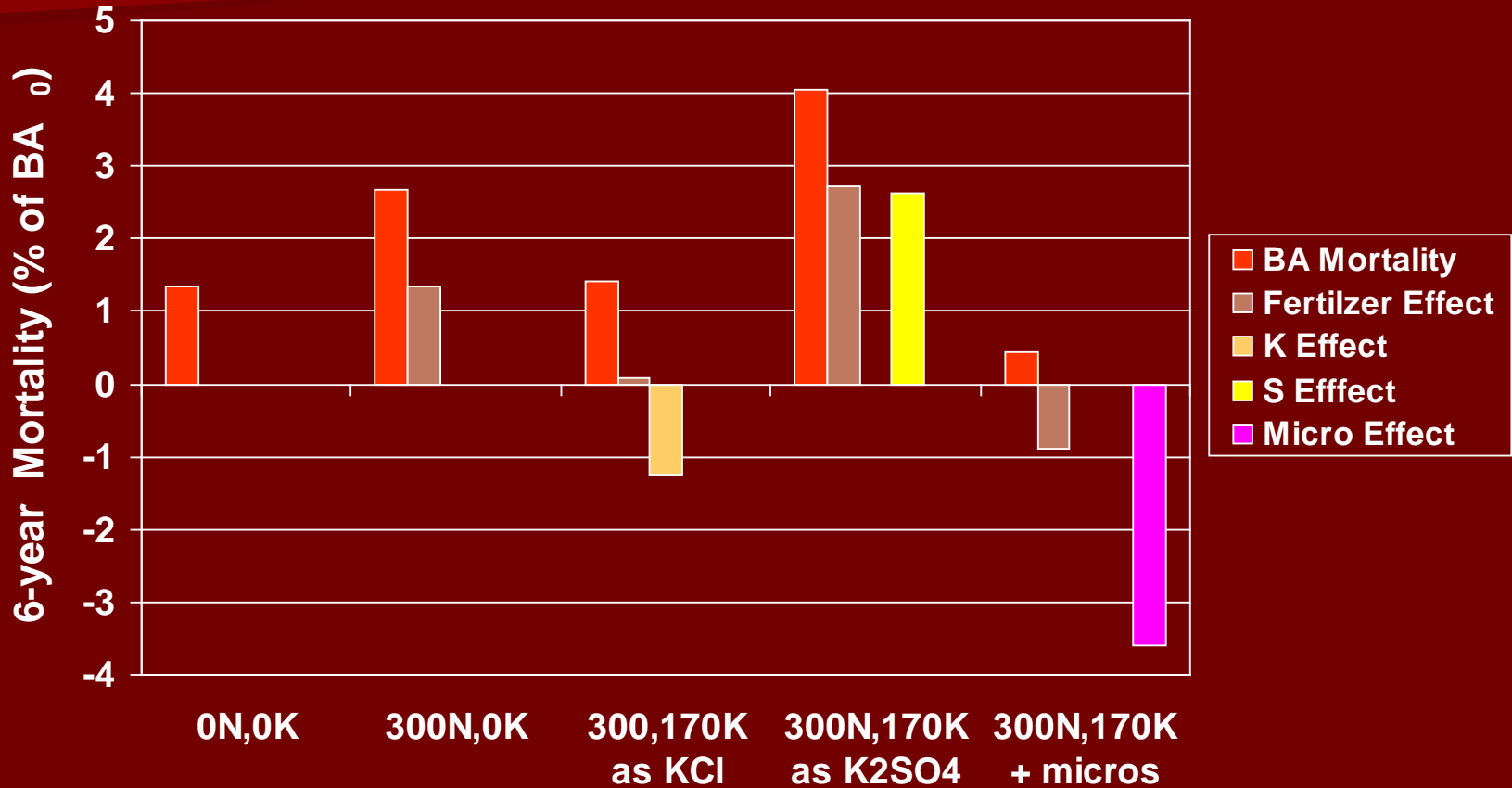
Forest Health: Effect of B fertilization on foliar B concentrations



Six-year PP basal area response: Forest Health Study



Six-year PP mortality response: Forest Health Study



Sulfur and micronutrients: Summary

- Foliage concentrations
 - PP foliar S concentrations increased to above-critical levels following S fertilization
 - PP foliar B, Mo, Cu and Zn concentrations increased following micronutrient fertilization, with B and Zn exceeding critical levels
- Growth response
 - S fertilization did not increase PP growth during either Umatilla or Forest Health studies
 - Micronutrient fertilization did increase PP growth during the Forest Health Study
- Mortality response
 - S fertilization increased PP mortality during the Forest Health study
 - Micronutrient fertilization decreased PP mortality during the Forest Health study

Summary: Response of mature PP stands to fertilization

- Positive growth responses were more often obtained on moister site types and better rock types
- N-fertilization often increased mortality, particularly on drier site types and poorer rock types
- K-fertilization did not increase growth but did decrease mortality, particularly on moister site types and better rock types
- *Effect of K on N-related mortality varies by rock type and vegetation series*
- S-fertilization did not increase growth rates, but sometimes increased mortality
- Micronutrient fertilization increased growth rates and decreased mortality

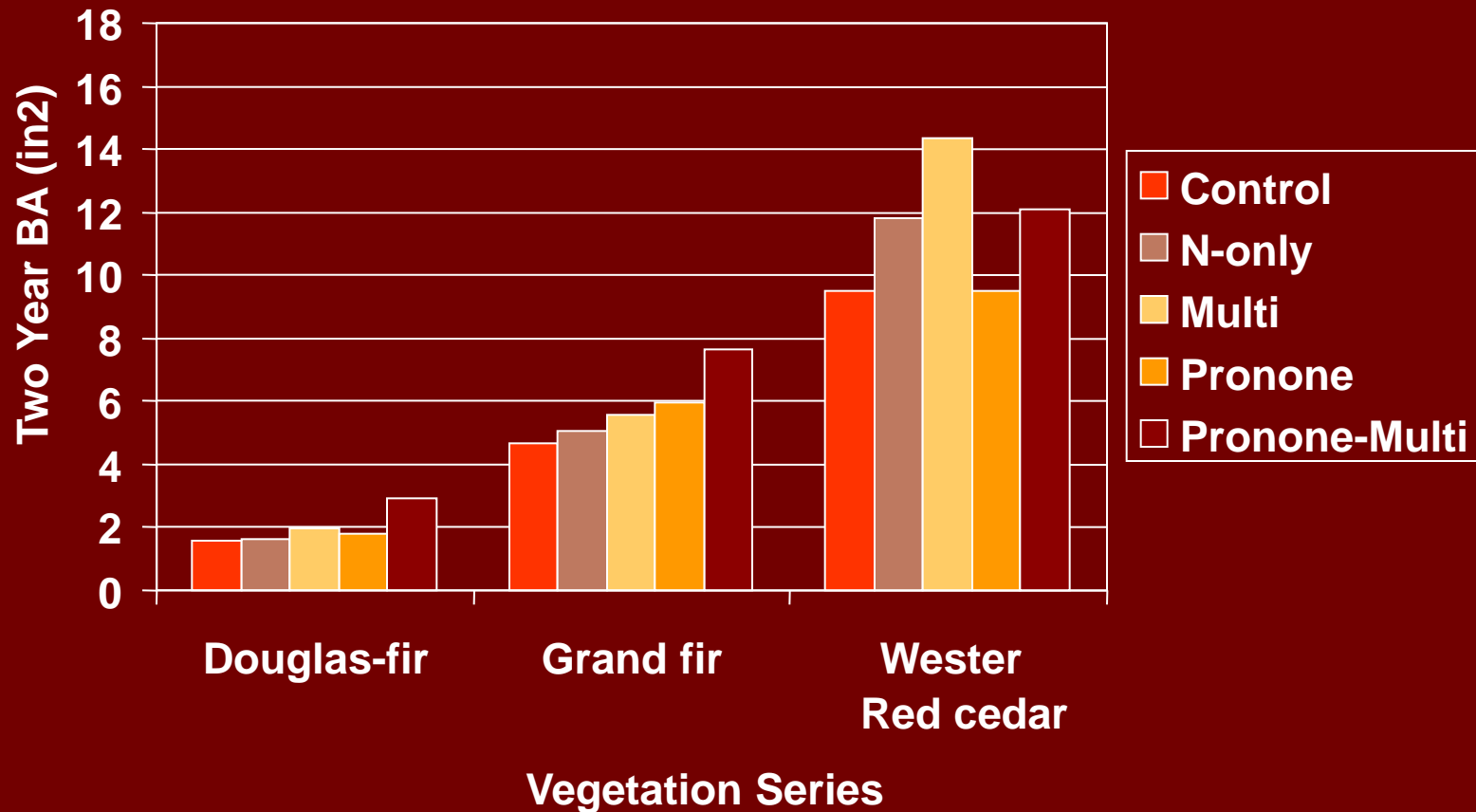
Young stand individual tree screening trials



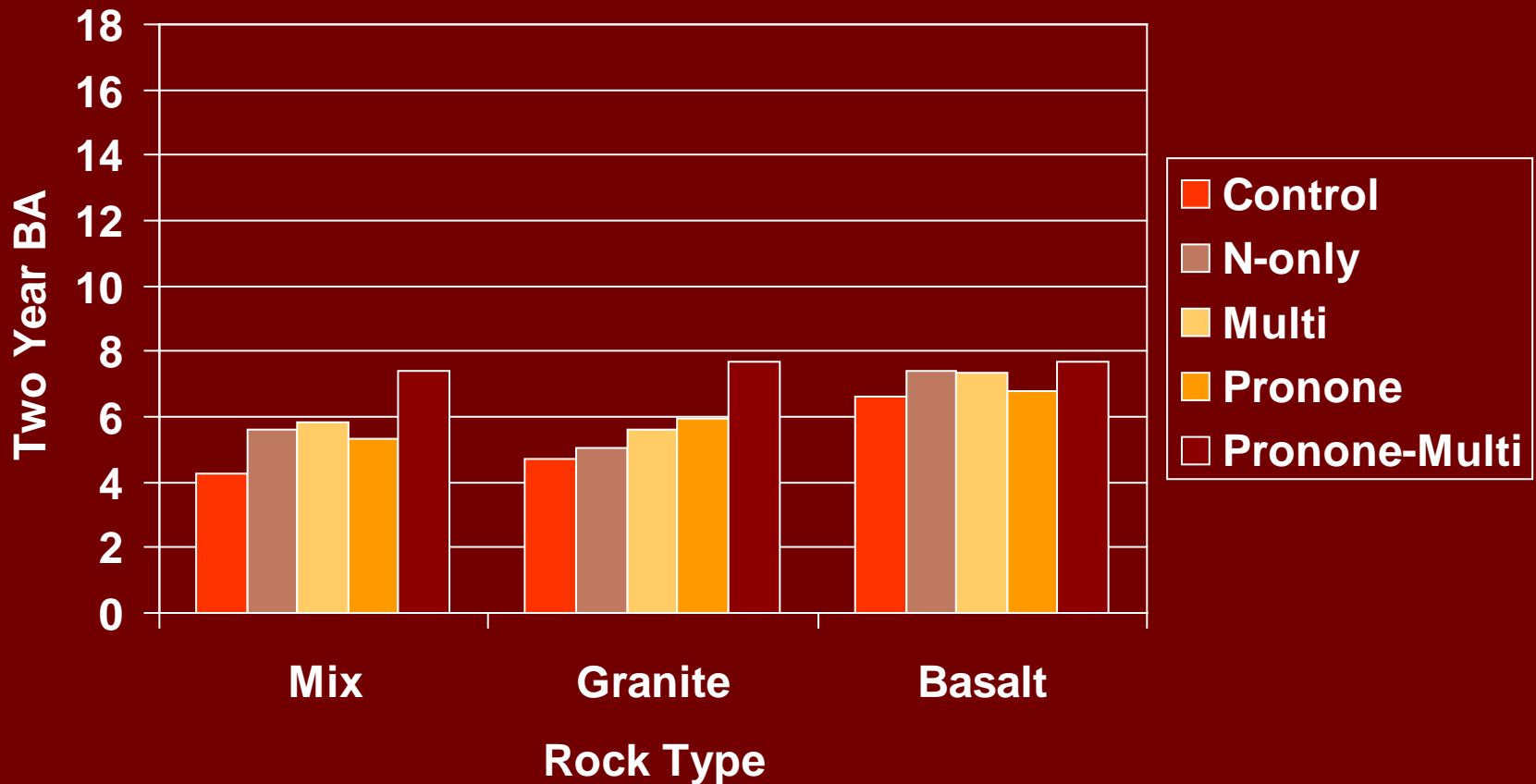
Individual Tree Screening Trials

- 29 PP trials established 1999-2000
- Primarily young (15-30 yr old) stands
- Rocks: metased., mixed, granite, basalt
- Veg.Series: PSME, ABGR, THPL
- Combination of fertilizer and herbicide treatments
- Foliage response is used to select those treatments which appear to give the best response
- Selected treatments may then be applied in long-term plot-based trials

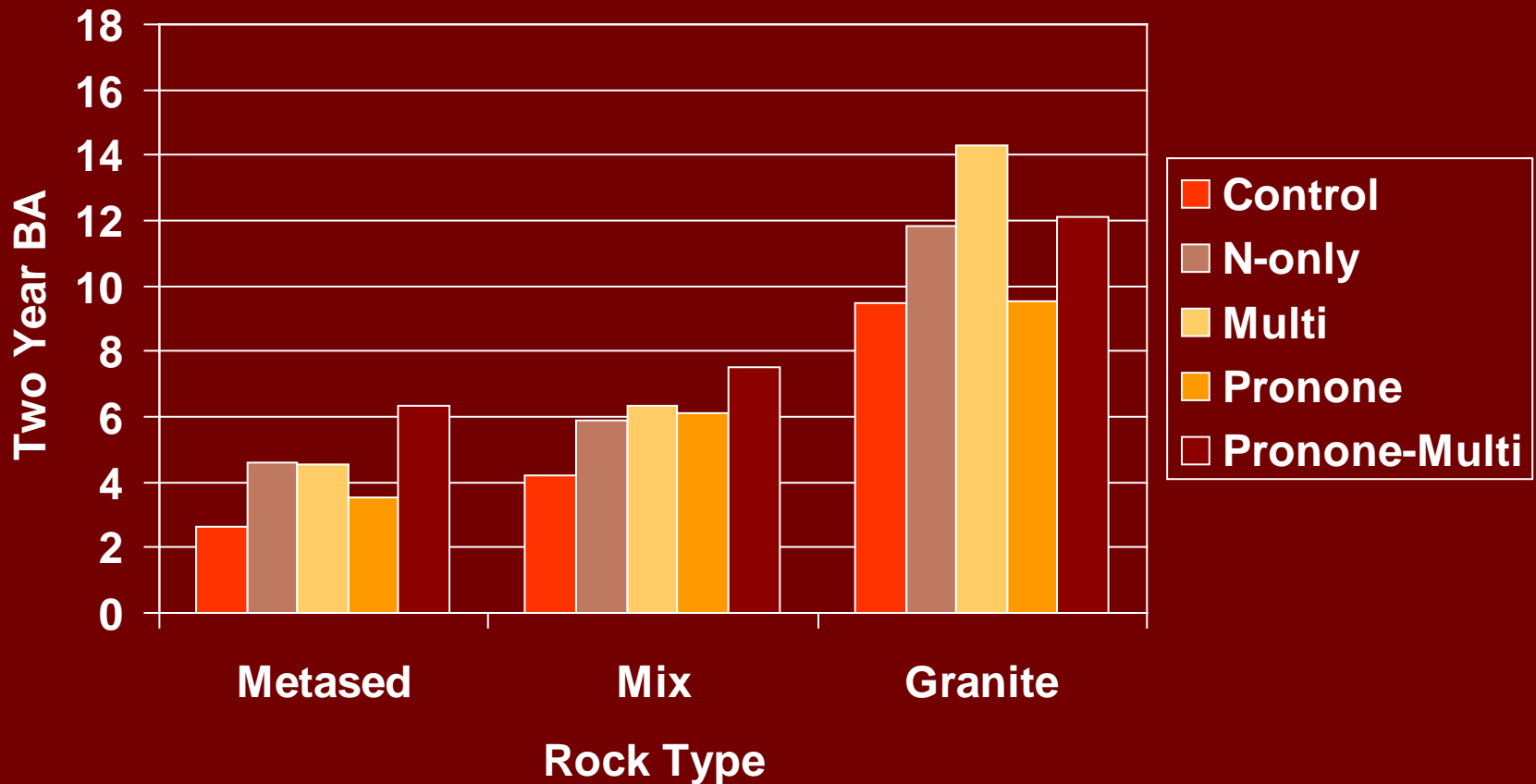
Granitic rocks: effect of vegetation series on two-year BA growth of young ponderosa pine



Grand fir vegetation series: effect of rock type on 2-yr BA growth of young ponderosa pine



Western red cedar vegetation series: effect of rock type on 2-yr BA growth of young ponderosa pine



Effect of fertilizer and herbicide on young PP trees: Summary

- Growth was greater on THPL vegetation series than PSME, with ABGR intermediate
- Moderate sites (ABGR and PSME) responded best to herbicide+multinutrient treatments, while moist sites (THPL) responded to multinutrient fertilizer alone
- On moderate sites (ABGR), rock type did not have a significant effect on growth or on fertilizer/herbicide responses, though growth on basalts was somewhat higher than on granitic or metasedimentary rocks
- On moist sites (THPL), granitic rocks showed higher growth and multinutrient fertilization response than mixed or metasedimentary rocks (no THPL sites on basalt for comparison)
- Management Implications
 - Ponderosa pine growing on good rocks and high moisture regimes may benefit from multinutrient fertilization alone
 - Ponderosa pine growing on most other rock types and moisture regimes will benefit from application of herbicide with the multinutrient fertilization