Estimating soil nutrient status using ion resin capsules and other methods

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Forest Health Nutrient Cycling Sites

	Installation	**Rock**	**Veg.Ser.**	**Treatment**
•	336 Spirit Lake	Glacial	THPL	C, NK
•	338 Snowden	Basalt	ABGR	C, NK
•	341 Grasshopper	Granite	THPL	C, NK
•	354 Huckleberry	Metased.	ABGR	C, NKS
•	355 Stanton	Metased.	THPL	C, NK
•	362 Haverland	Granite	ABGR	C, NKS/micros

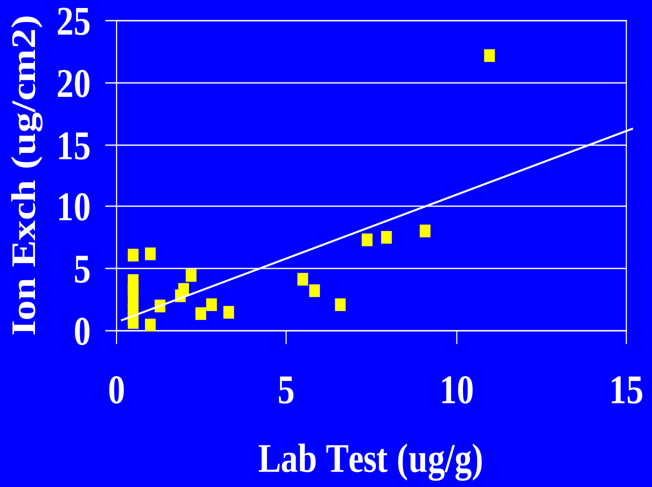
Soil Analyses for Forest Health Sites

- Ion Exchange Resins
  - Buried on two plots at each of the six sites
  - Buried in three pits and four horizons on each plot
  - Burial time: 1 year
- Standard Soil Tests
  - Soils collected from the three pits on each plot and composited by horizon (A,B,C,D)
  - Analyzed by UI soil testing laboratory

Correlation Analysis: Ion Exchange vs. Soil Lab Test

- Significant correlation for:
  - P (r^2=.69)
  - Mn (r^2=.67)
  - Extractable K (r^2=.47)
  - Mg (r^2=.44)
  - NH_4^+ (r^2=.41)
  - Zn (r^2=.39)

P (r2=.69)



- No correlation for remaining elements
  - NO_3^-, S, Ca, B, Cu, P, Fe, total K

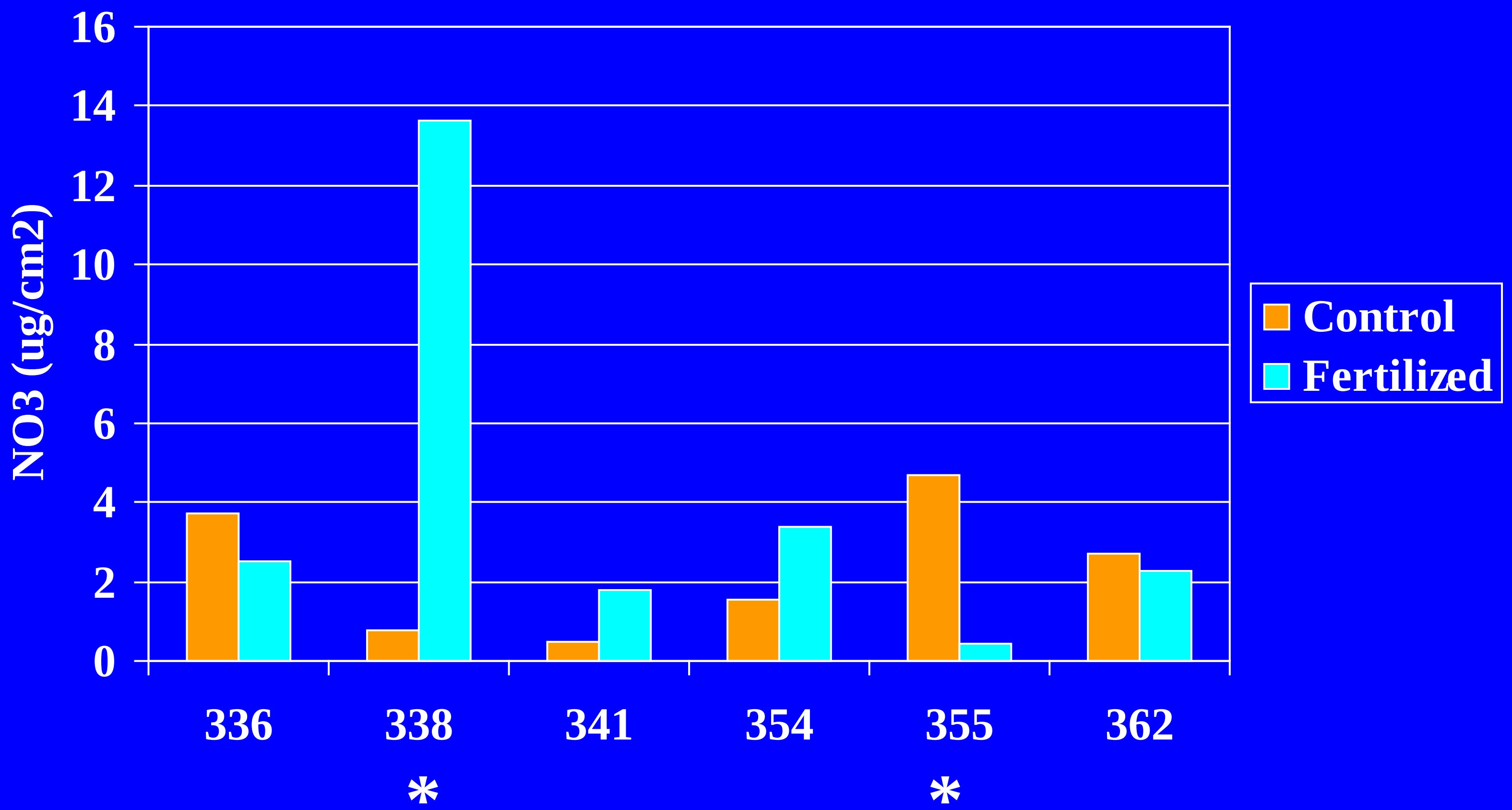
Correlation Analysis Results

- More than half the elements tested showed no correlation between ion exchange data and lab test data
- Detection limits for ion exchange analysis appear to be better than standard soil test procedures

Ion Exchange Resins, Tongue Depressors, and Forest Floor on Forest Health Installations

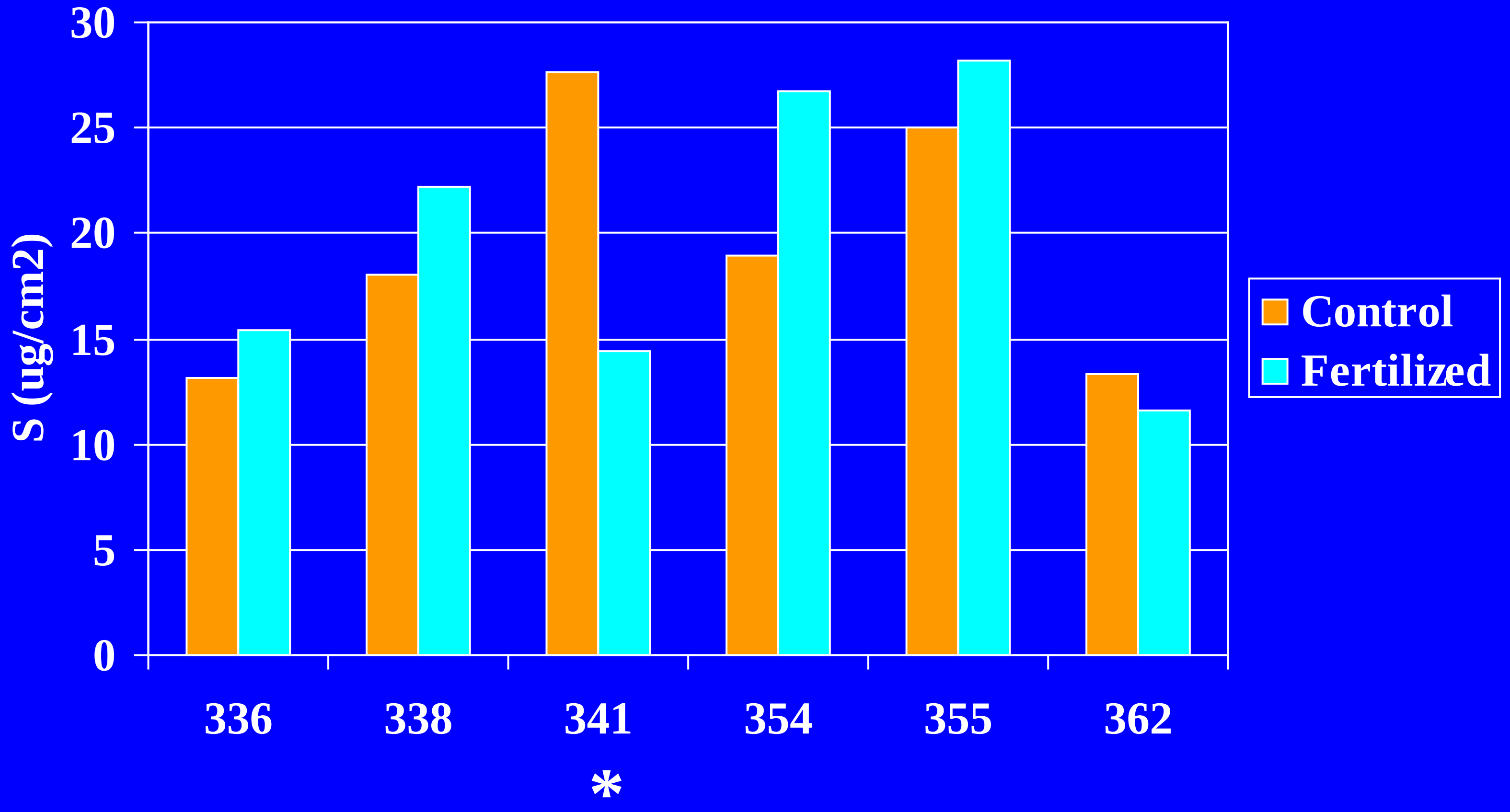
- Analyzed for
  - Installation
  - Treatment
    - Control
    - NK, including NKS and micro trts
  - Horizon (ion exchange and tongue depressors only)
    - A – Forest Floor/ Mineral Soil Interface
    - B – Bw horizon
    - C – BC or 2BC horizon
- Fertilizer was applied 5 to 7 years prior to current sampling

NO_3^- Availability by Installation and Treatment



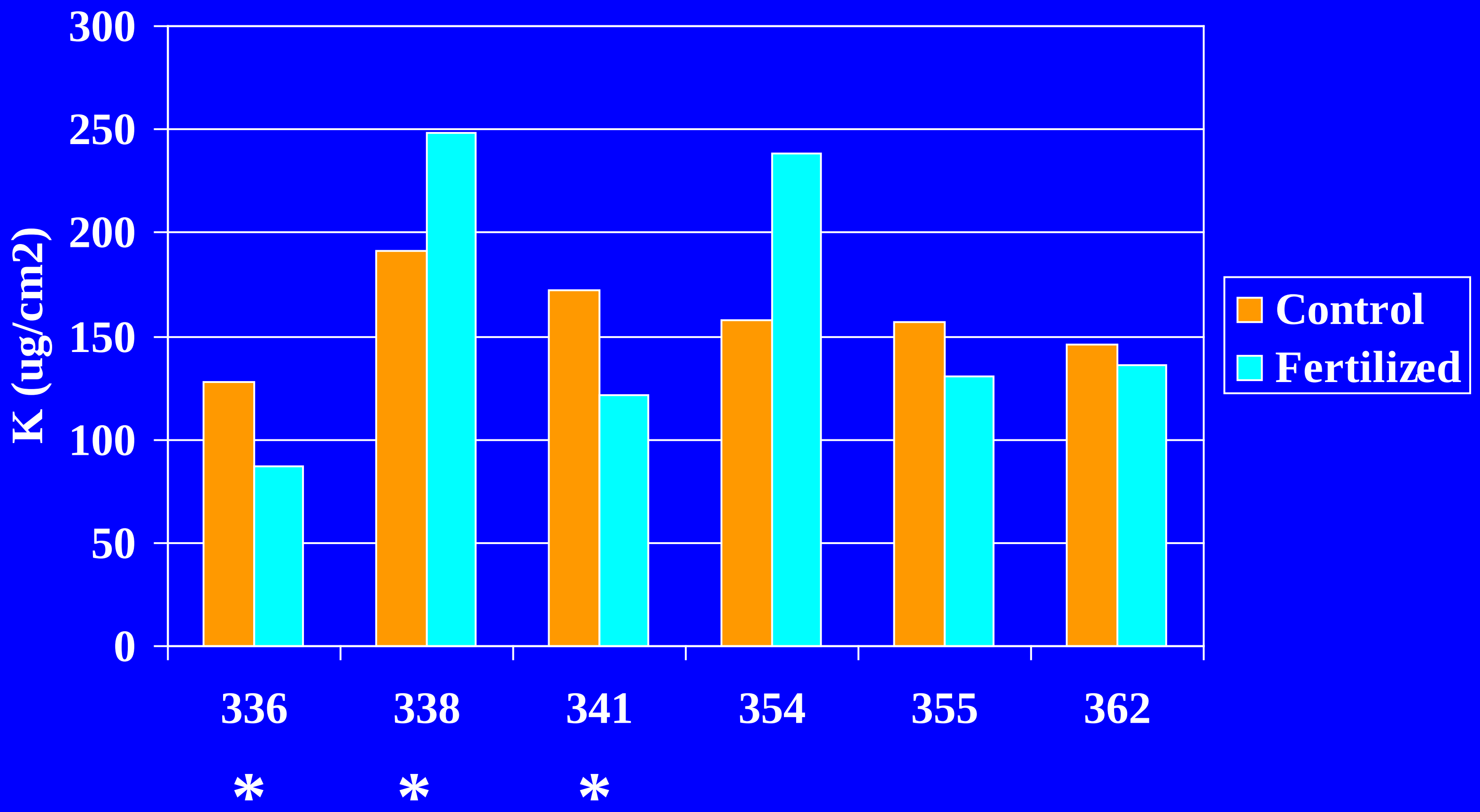
* Significant at p=.10

S Availability by Installation and Treatment



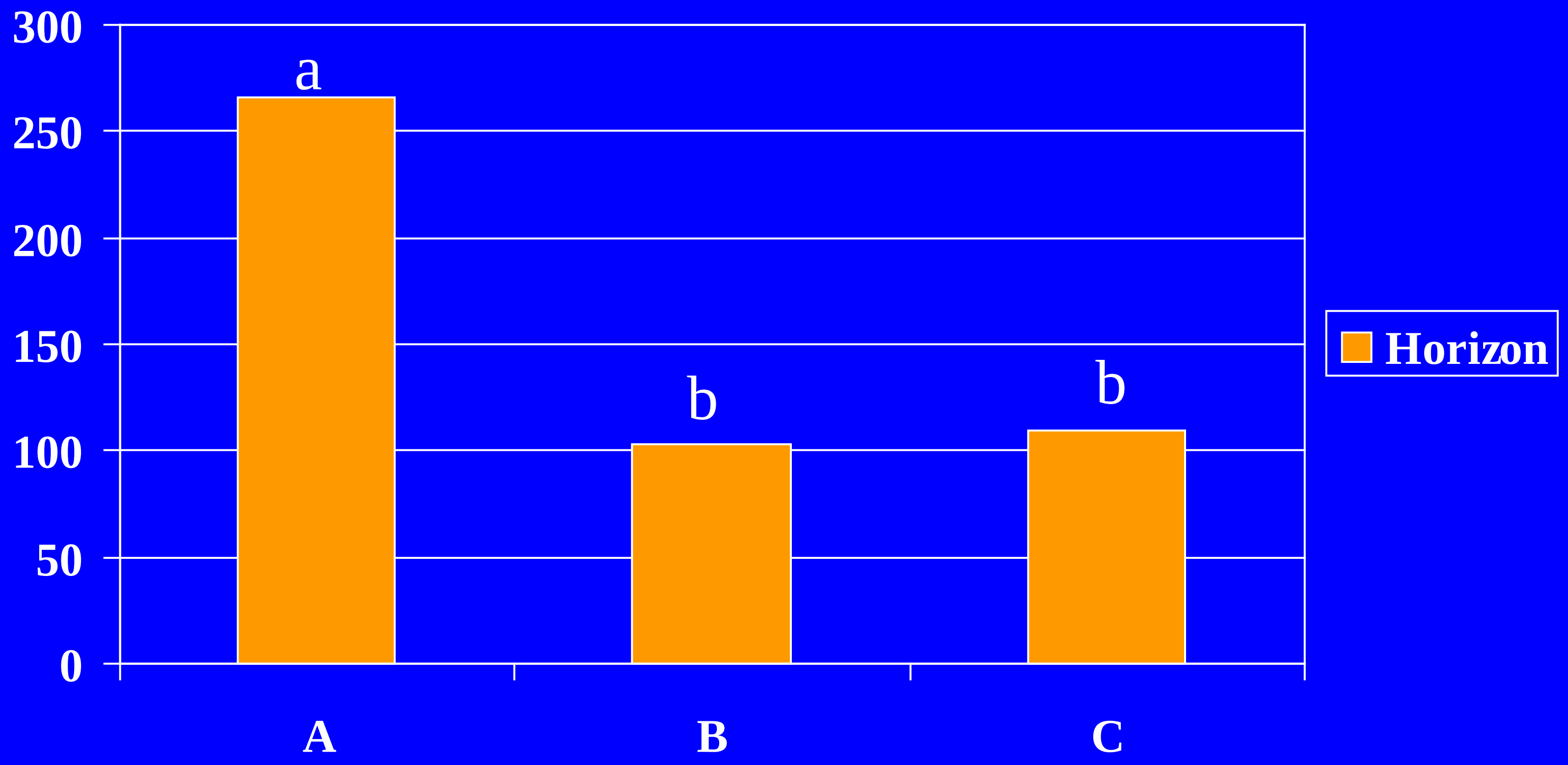
* Significant at p=.10

K Availability by Installation and Treatment



* Significant at p=.10

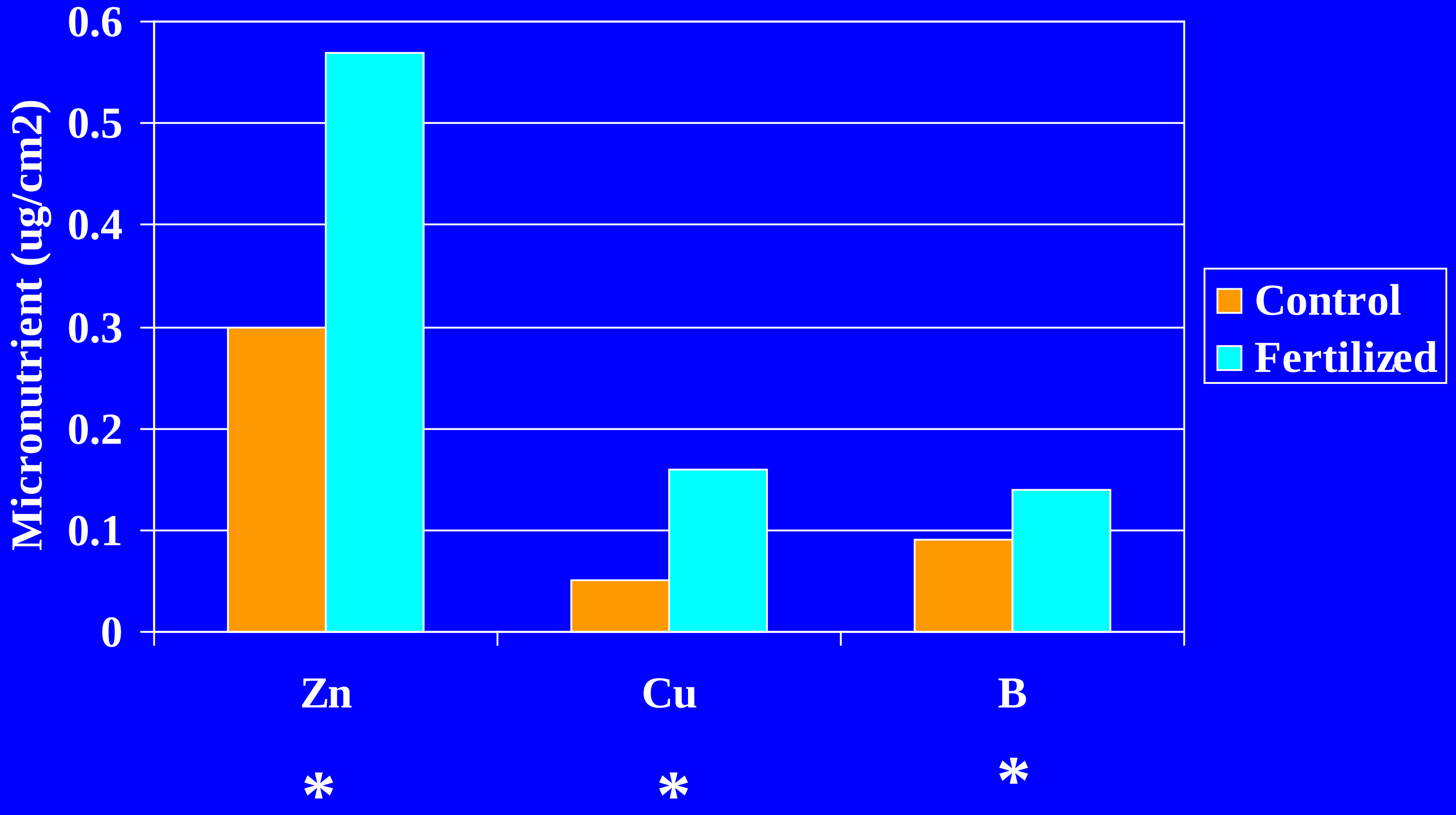
K Availability by Horizon



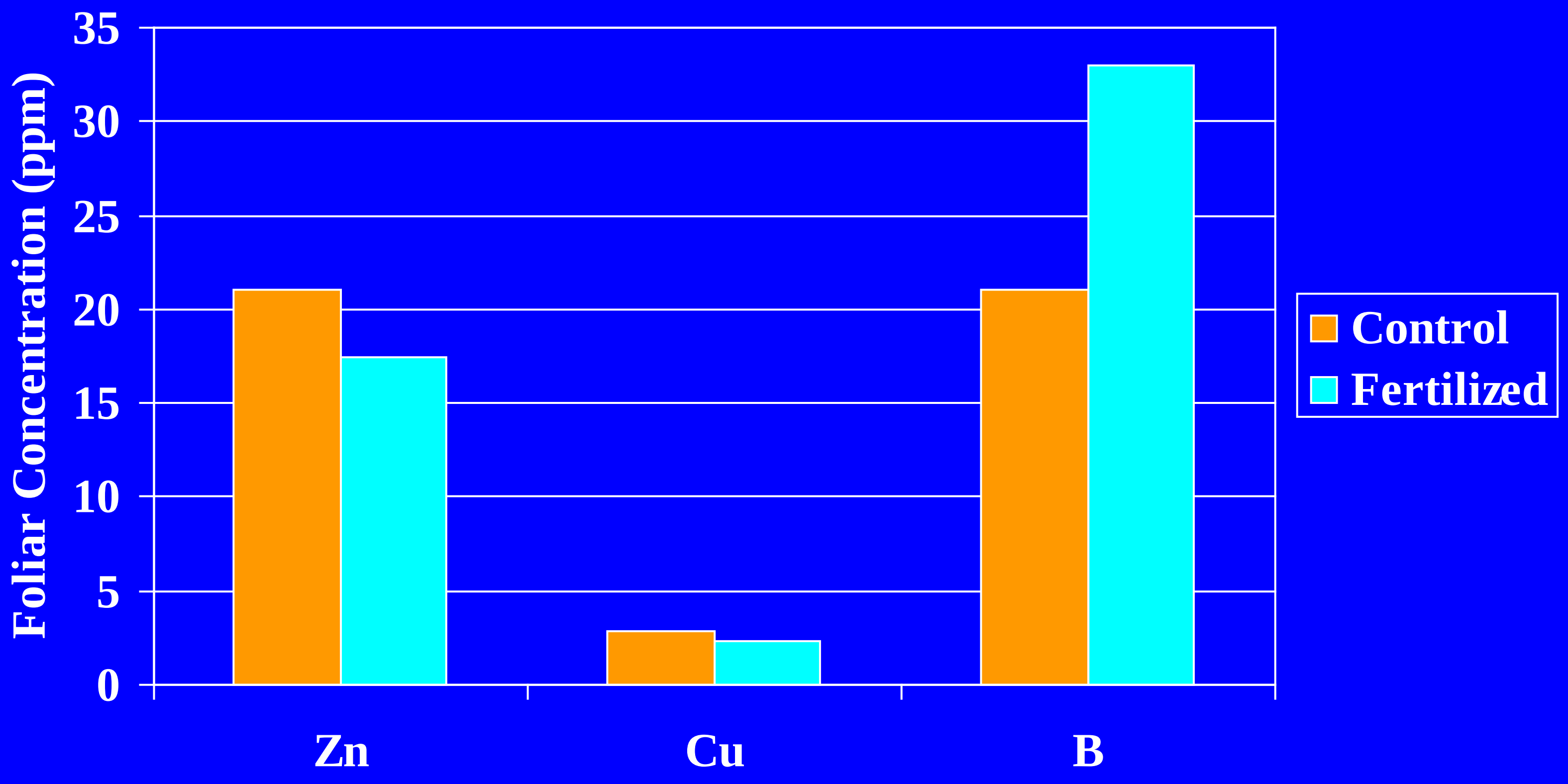
Ion Exchange Analysis of NO_3^-, S and K

- All installations responded differently from each other – no overall vegetation series or rock effects were detected (all elements including N, K and S)
- No consistent trends in NO3, K or S on control vs. fertilized plots
- Higher K level was detected in the upper soil horizon, reflecting its propensity to be cycled from deeper in the soil profile, through vegetation/ litterfall, to the soil surface
- Lack of overall NO3 and S treatment effects may have been due to the 5-7 year time since fertilization and high mobility of those elements
- Lack of overall K effect may have been due to high cycling rate, and likelihood of K to become fixed in soil clay minerals

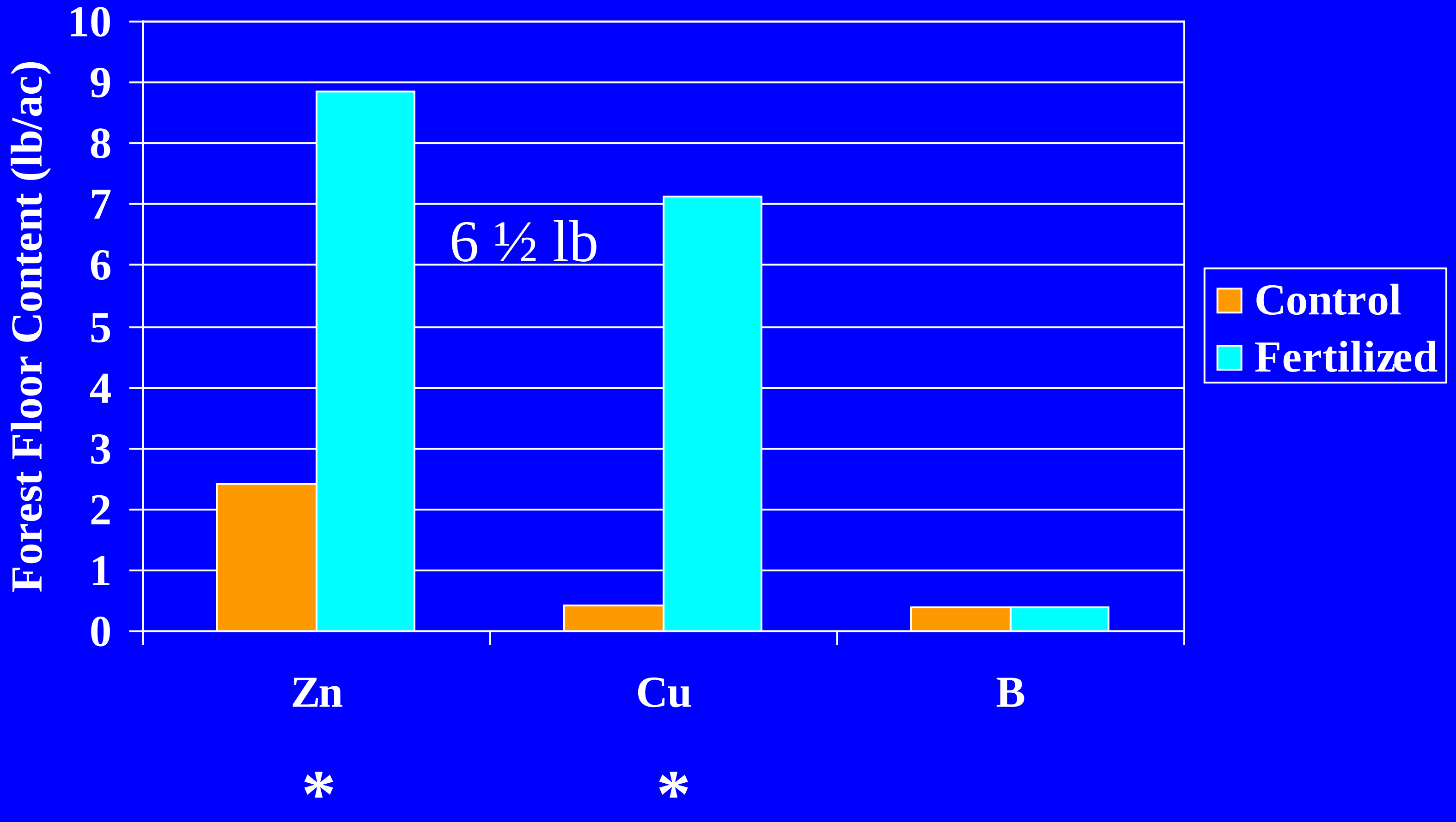
Year 5 Micronutrient Availability by Treatment for Inst.362



Year 1 Douglas-fir Foliar Nutrient Concentrations at Ins.362



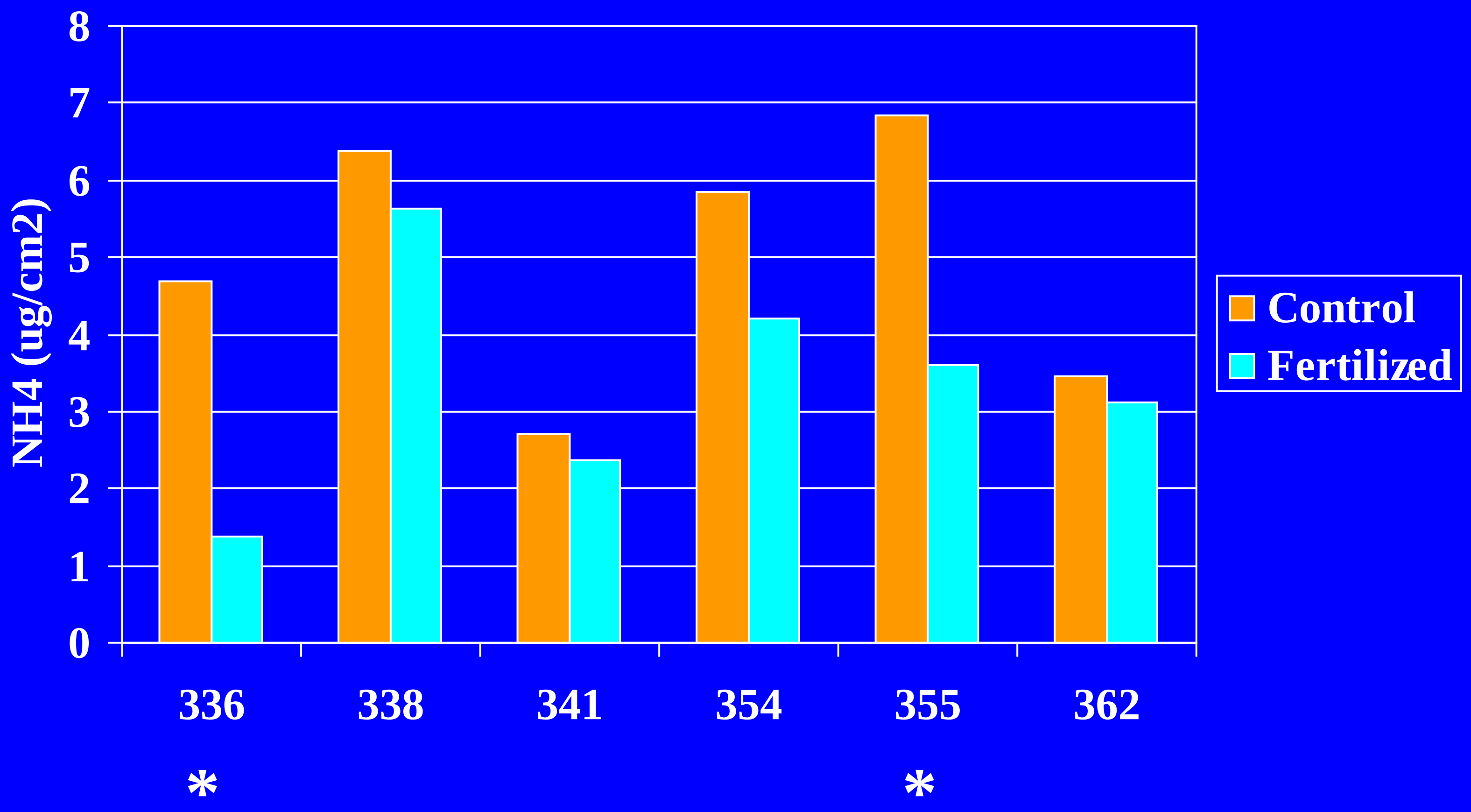
Year 5 Forest Floor Nutrient Contents at Ins.362



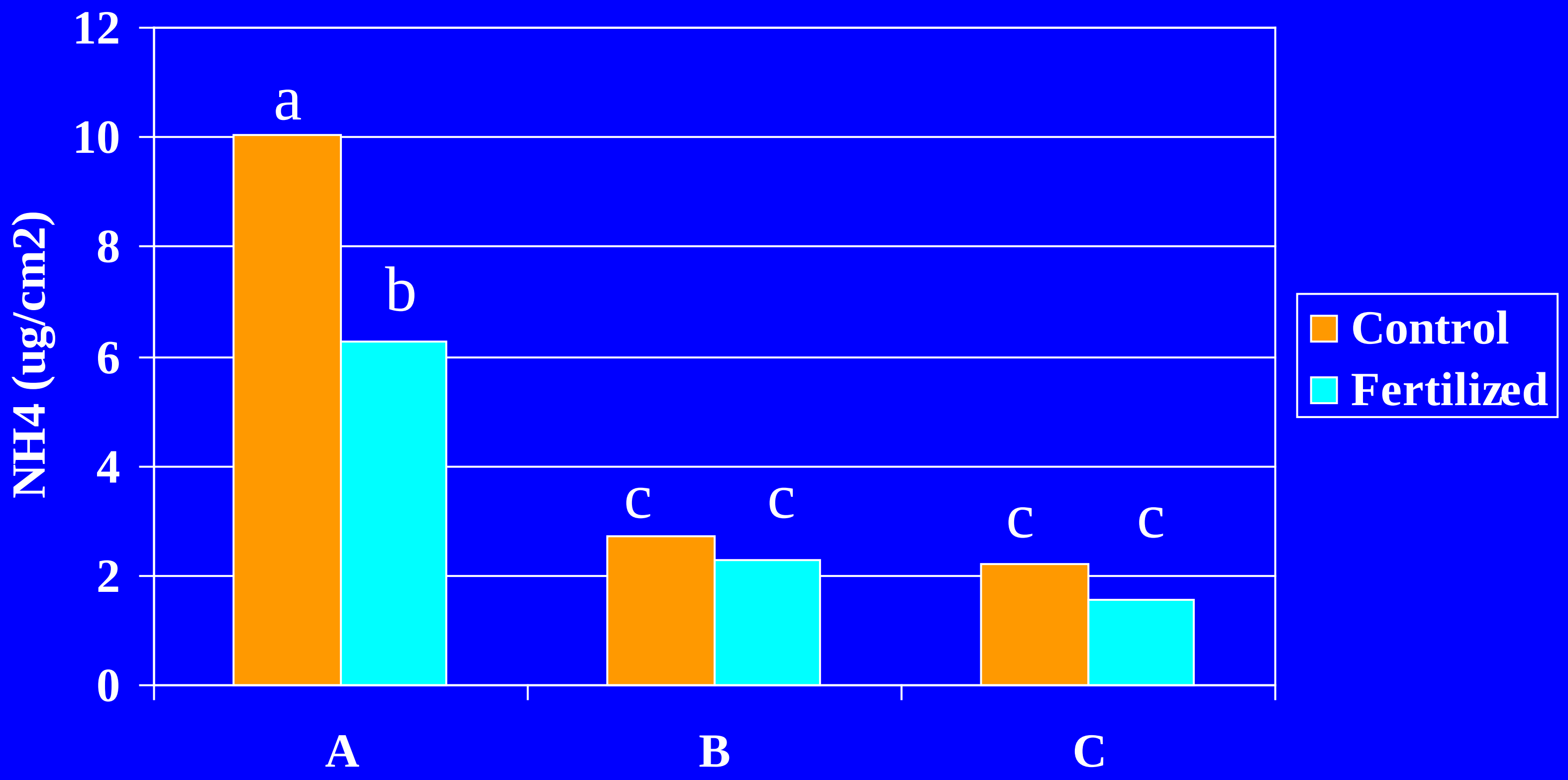
Micronutrient Treatment Effects

- Zinc and Copper
  - Not taken up by trees in the first year after fertilization
  - About 6 ½ lb/ac of the 10 lb/ac applied of both elements is still in the forest floor five years later
  - Currently, more Cu and Zn are soil-available on the fertilized plot compared to the control plot
- Boron
  - Taken up by trees in the first year after fertilization
  - Not being held in forest floor
  - Five years later, more B is soil-available on the fertilized plot
- Growth or physiological response to Cu and Zn might have been delayed by those elements being retained in forest floor, but soil tests indicate that these elements are now becoming plant available

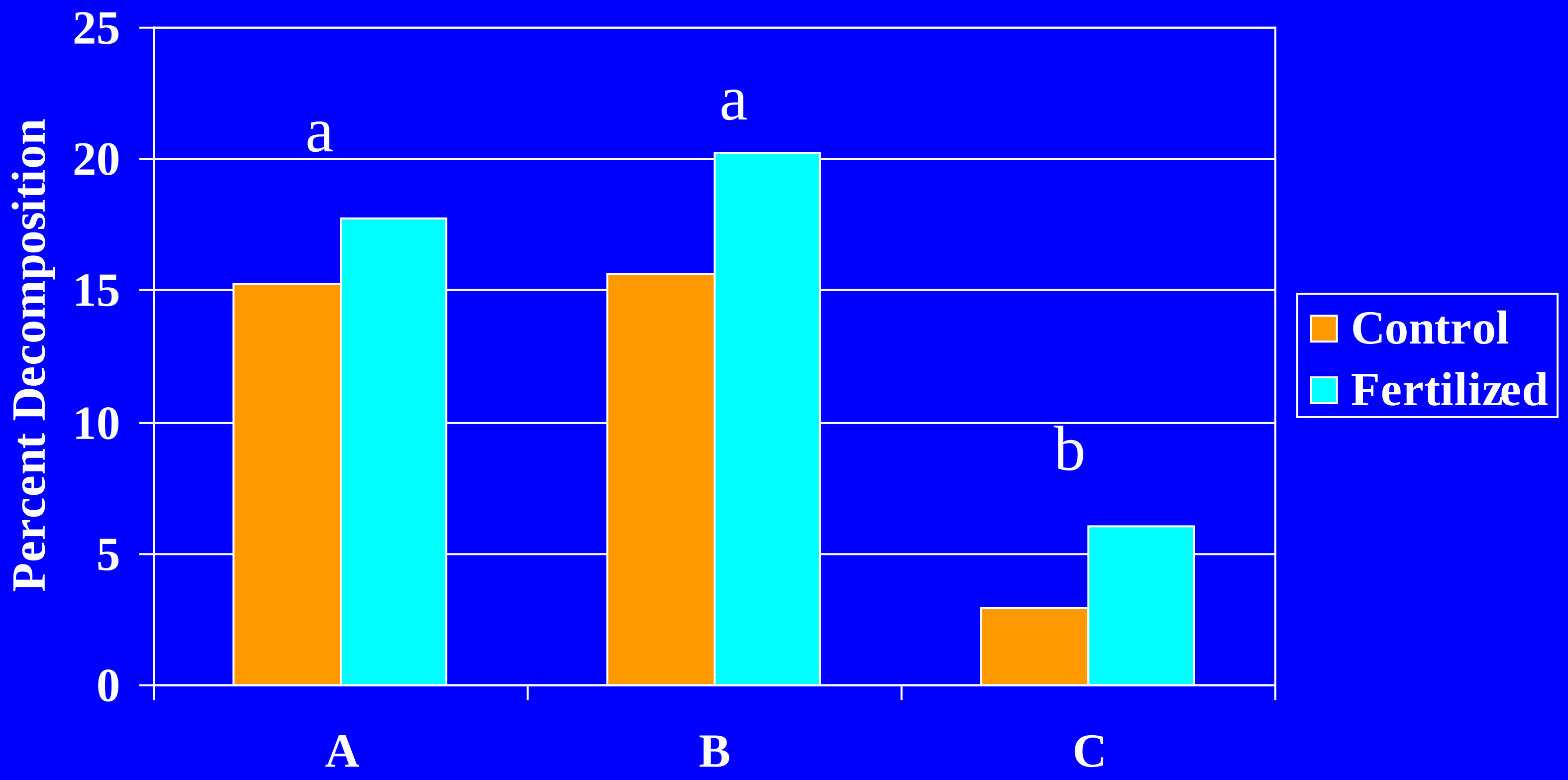
NH_4^+ Availability by Installation and Treatment



NH_4^+ Status by Horizon and Treatment



Tongue Depressor Decomposition by Horizon and Treatment



Why Less NH_4^+ on N-Fertilized Plots?

- Applied N is immobilized by (a) plant uptake, and (b) bacterial microorganisms which ingest N as a food source
- We know from foliar data that significant amounts of applied N were immobilized through tree uptake
- By applying N fertilizer, we also likely increased the microbial population, thereby increasing the amount of bacterial N immobilization on that plot
- Tongue depressor decomposition tended to be greater on the fertilized plots, also implying a greater level of microbial activity on the fertilized plots

What about microbial populations?

- Other researchers have shown N fertilization to increase the bacterial/fungal ratio of microbial biomass (Forge et al. 2001*)
- We do not have data on bacterial/ fungal biomass at our sites, but we do have some data showing a reduction in fungal diversity following fertilization
- This reduction in fungal diversity might reflect an increase in the bacterial population and increased competition for resources like NH_4^+

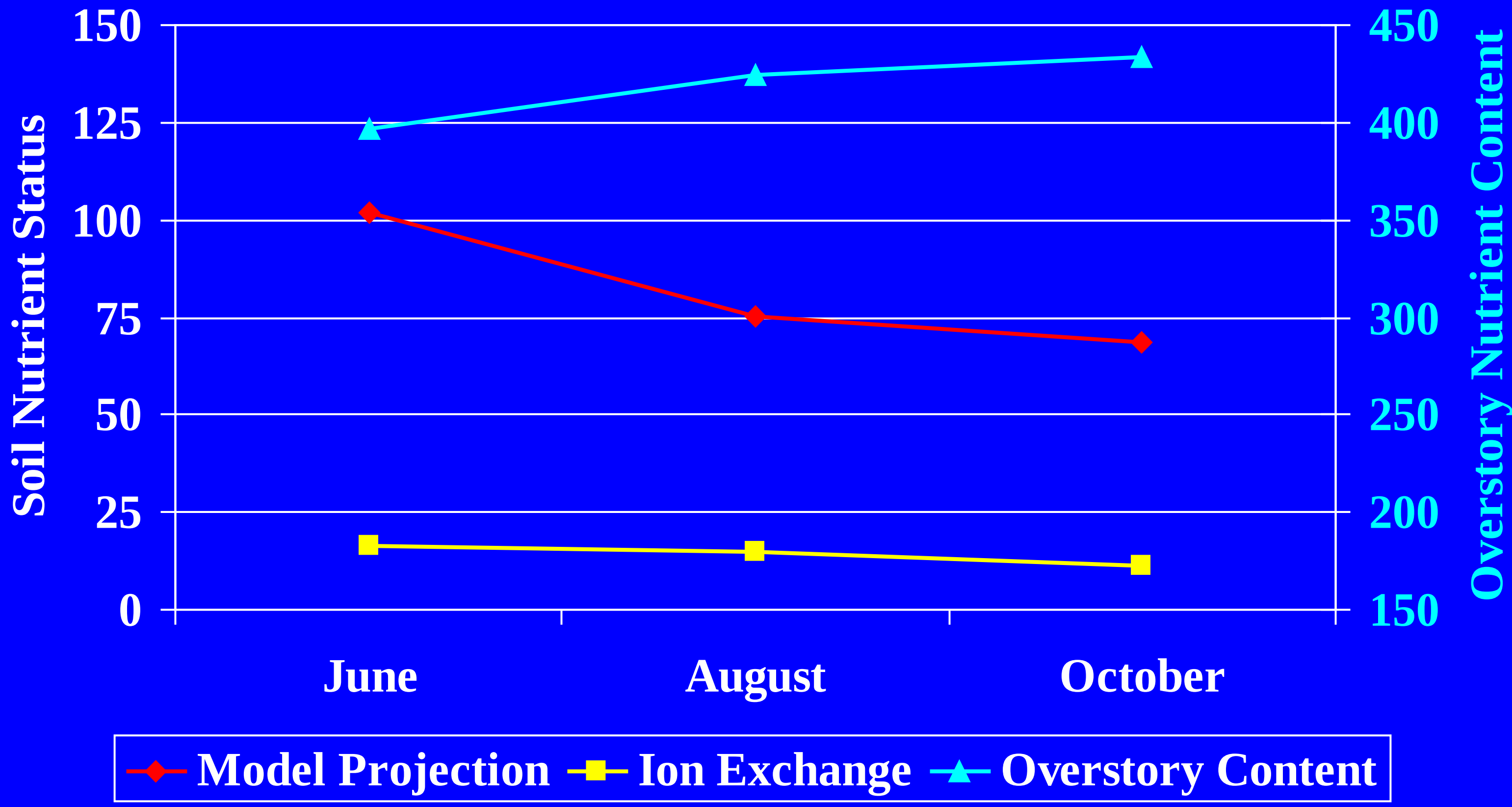
*Forge, T.A., A.M. Muehlchen and S.W. Simard, 2001. Influences of clearcut harvesting and fertilization on structure and function of the soil food web in ICH forests of southern interior British Columbia. BC Ministry of Forests Research Program, Extension Note 59, 8pp.

Soil Nutrient Estimation Within the Nutrient Cycling Model

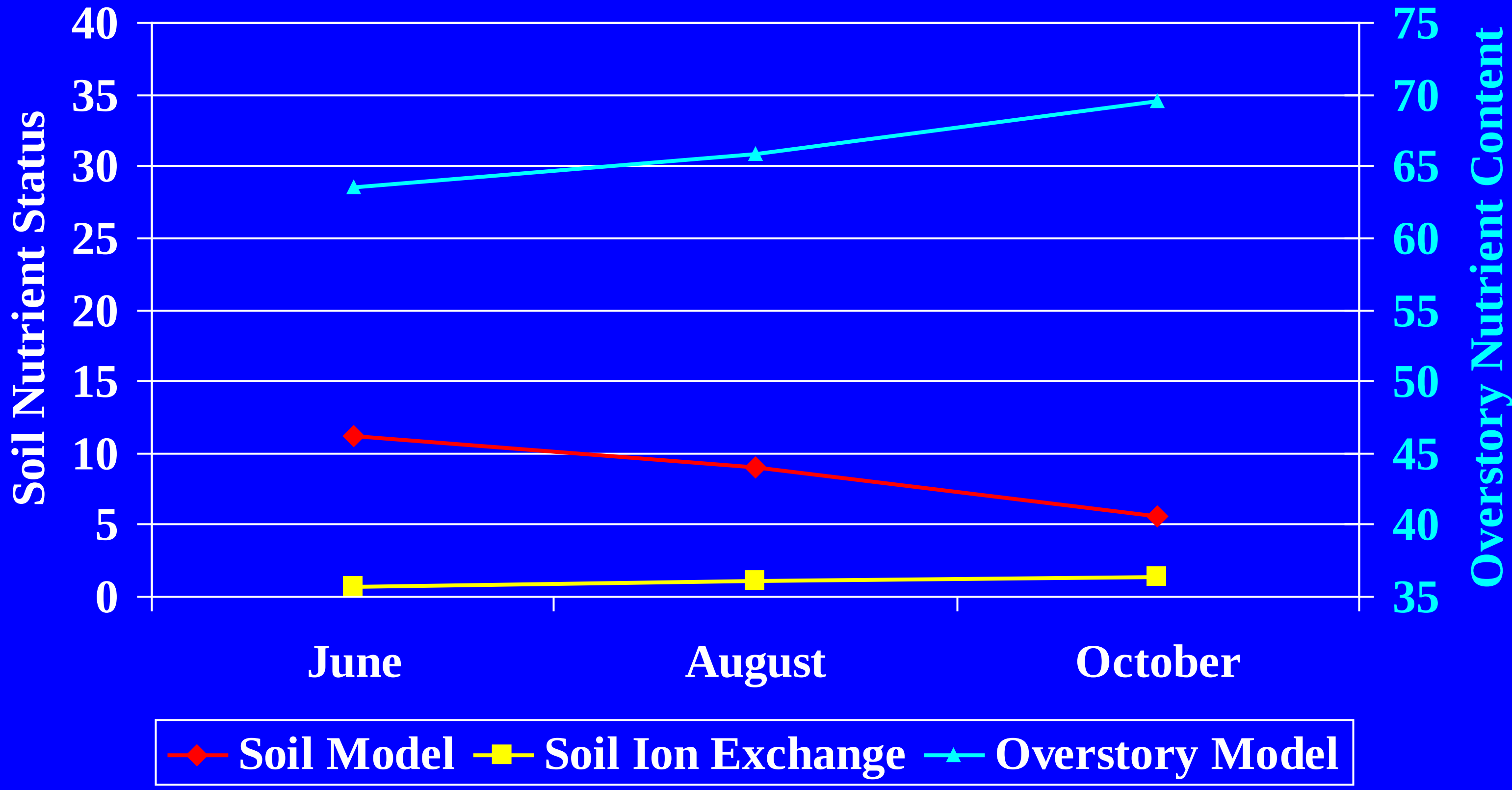
Mallory Creek Example

- Nutrient cycling model data for the 1999 growing season included:
  - Estimated/ projected overstory contents
  - Projected soil content
- Soil ion exchange data for the 1999 growing season was averaged for the same points in time

Seasonal N Levels of Projected Soil Content, Ion Exchange Soil Measurement, and Overstory Content



Seasonal P Levels of Projected Soil Content, Ion Exchange Soil Measurement, and Overstory Content

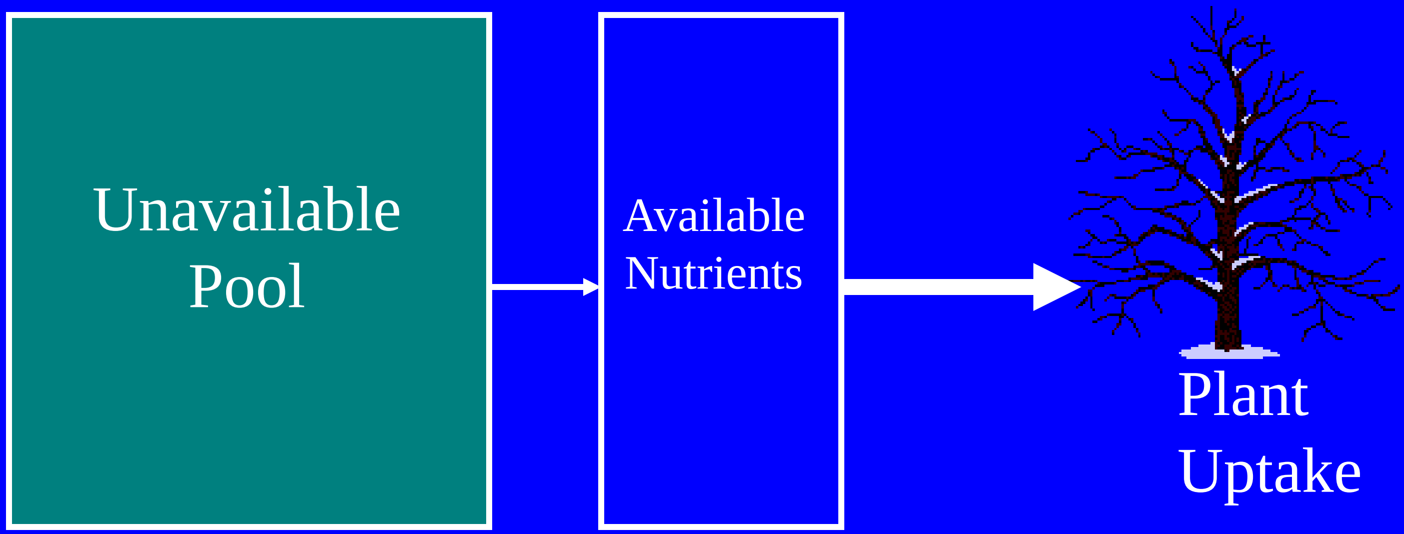


Mallory Creek Soil Box Nutrient Projections

- “Soil Box” utilized standard laboratory soil results to produce the initial content, and thereafter fluctuated based on other inputs and outputs
- According to model projections, soil N, Ca, Mg and P supplies were depleted within a few years, and other elements except Fe and S also gradually decreased over time
- According to ion exchange analysis, this depletion was not ‘real’

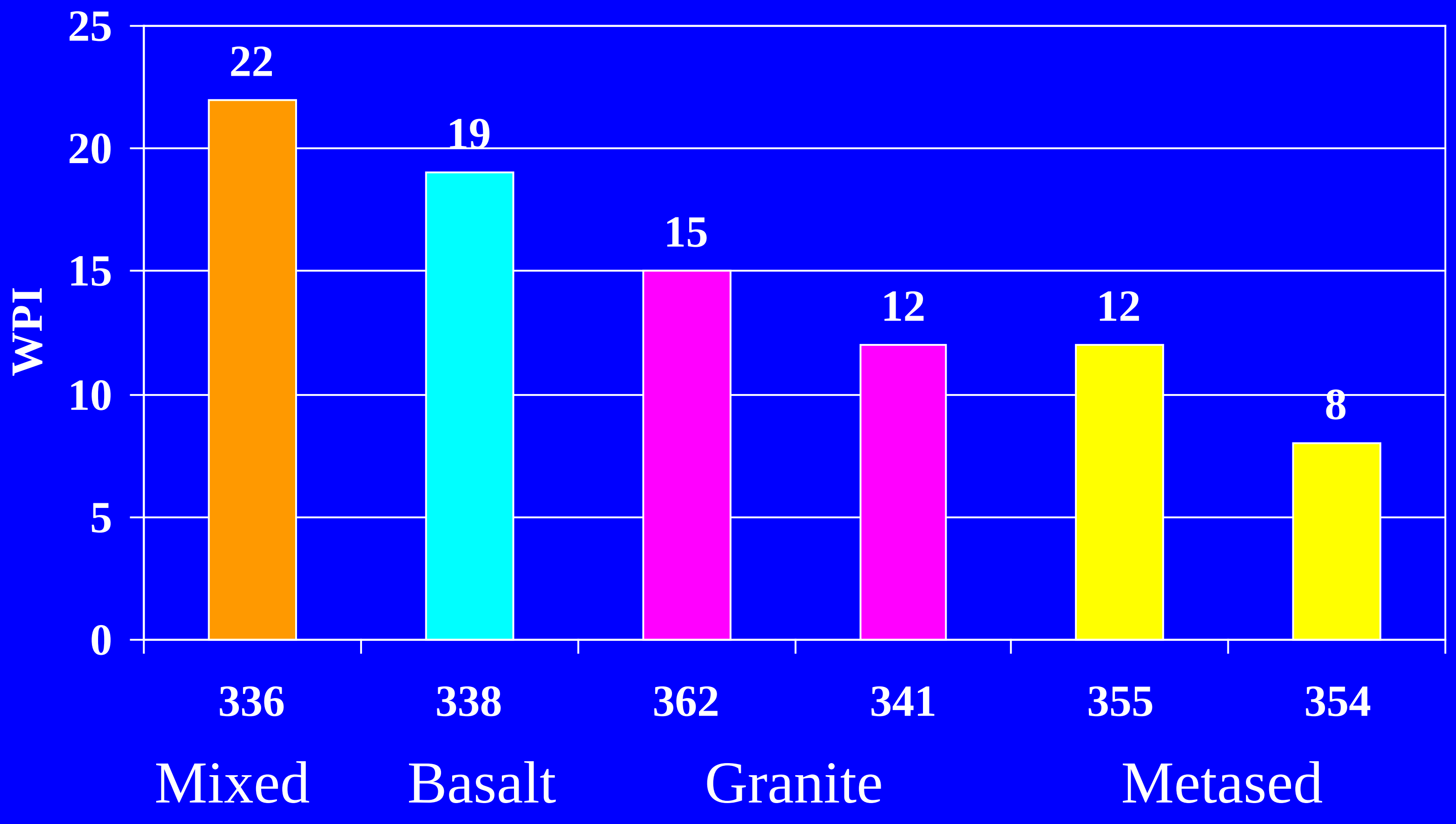
Reason for Projected Soil Depletion

- Model does not account for the buffering capacity, or rate of replenishment from the non-available to the available pool



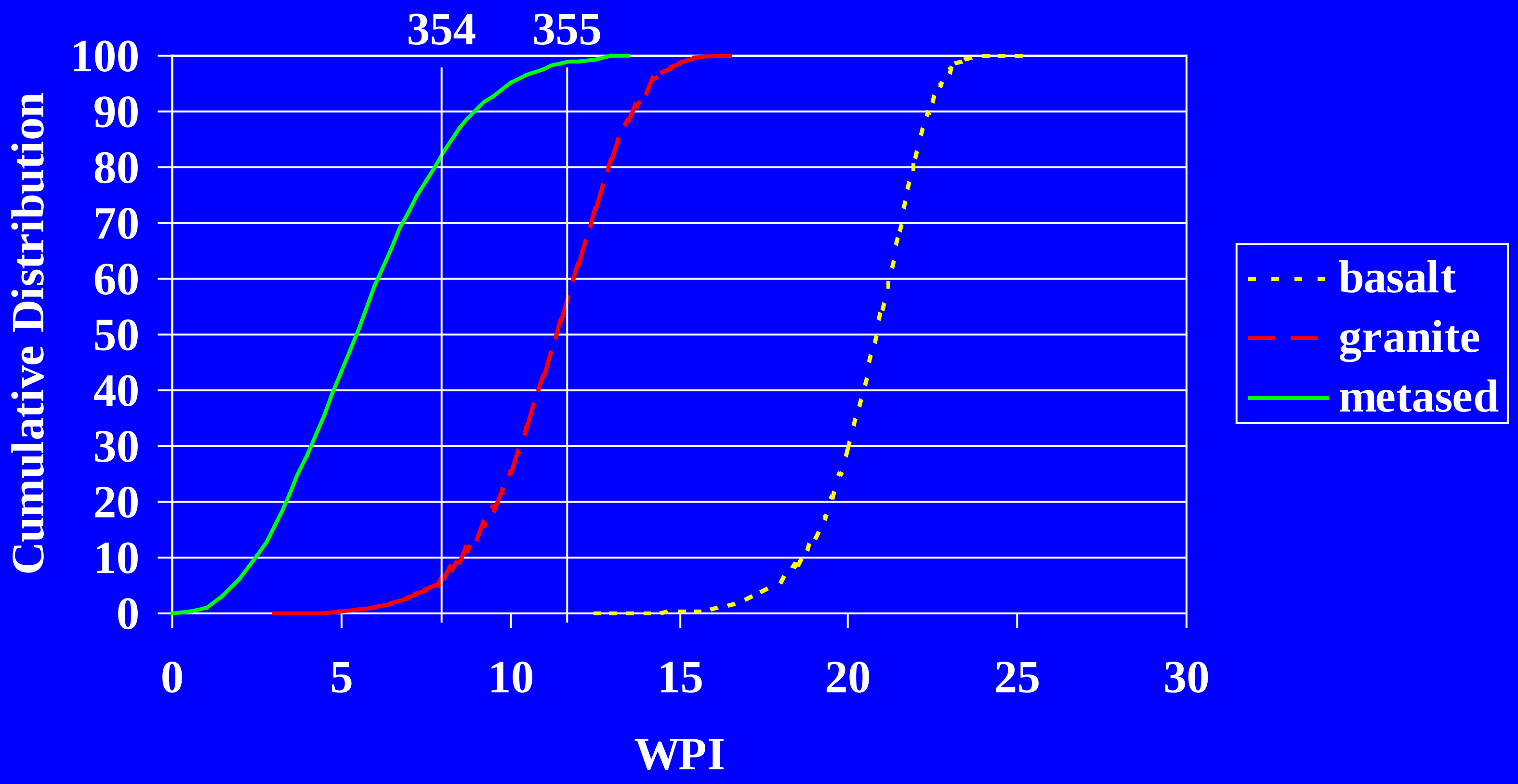
- Ion exchange resins can be used to detect these changes in soil nutrient availability

Rock Inputs: Weathering Potential Index

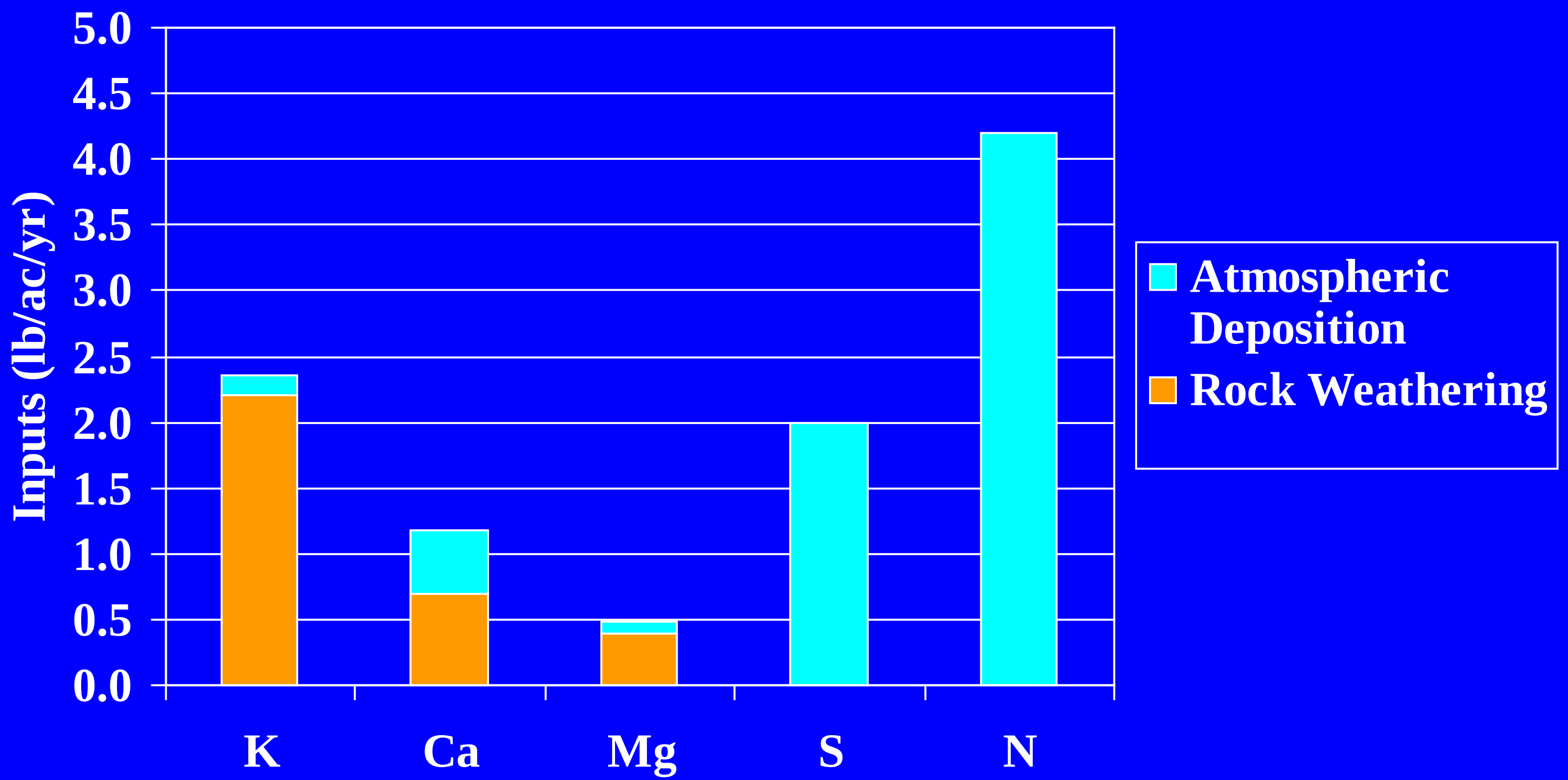


Weathering Potential Index

Cumulative Distribution Across 31 IFTNC Sites

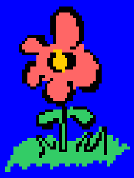


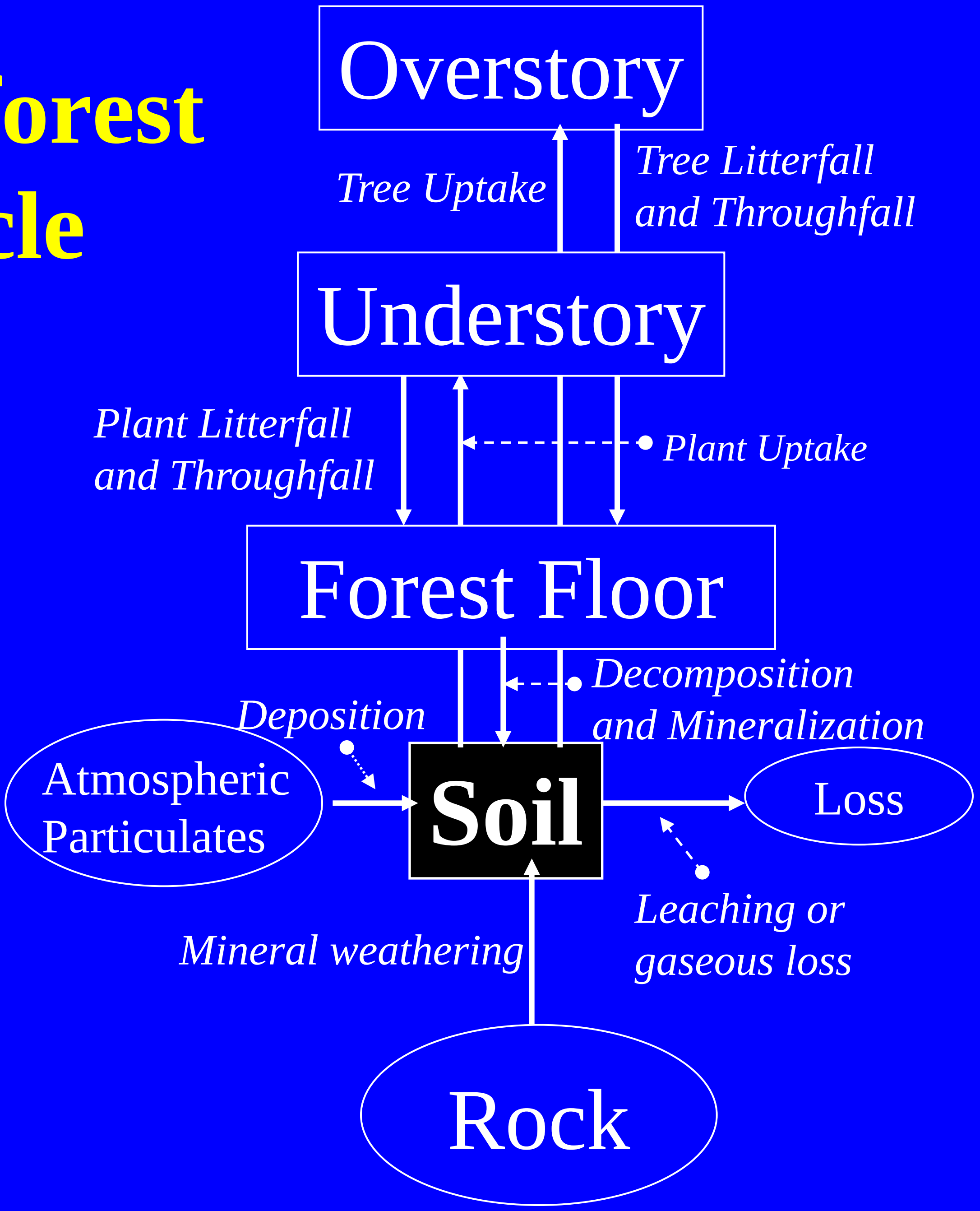
Estimated Rock Weathering Rates and Atmospheric Deposition*



* Mallory Creek Project Site; metased; WPI=8.3

Modeling the forest nutrient cycle





Soil: The Future of the Black Box

- We have a structure within which to evaluate soil nutrient status
- Mallory Creek example provided valuable information on what inputs and outputs need to be monitored more closely
- We have also gained a better understanding of soil nutrient dynamics
- Overall, methodologies and techniques are in place to quantify the soil ‘black box’ using ion exchange resins

Future Work Using Ion Exchange Resins

- We have gained a better understanding of soil nutrition by deploying ion exchange resins on a variety of sites and a few past management regimes
- Future work could include deploying ion exchange resins across a variety of sites representing:
  - past management regimes
  - rock types
  - habitat types
  - stand types
- Use nutrient status based on ion exchange results to index long-term site productivity