Forest Nutrient Research: Past, Present & Future

Mark Kimsey

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Moscow, ID

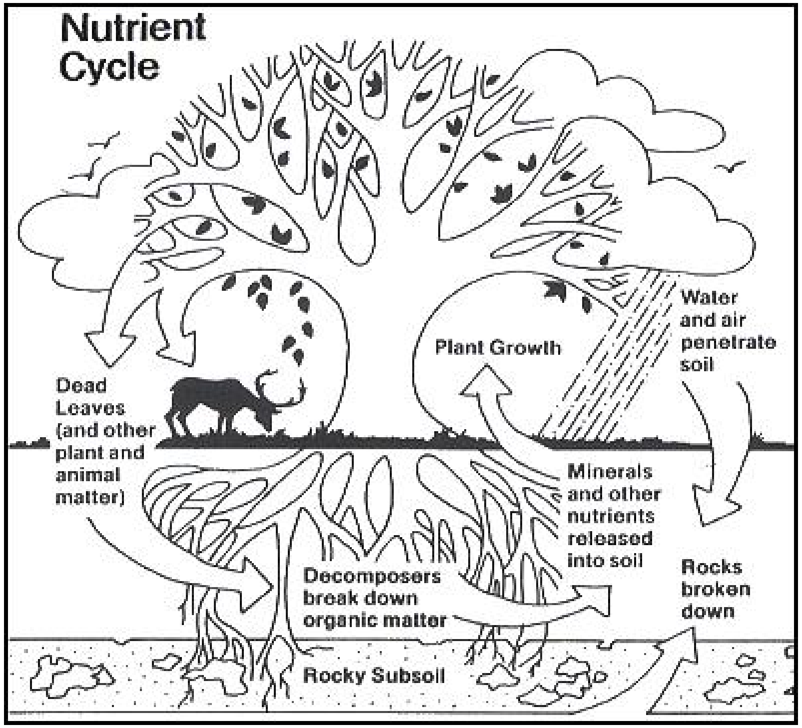
Overview

- Context – The Basics
  - Plant Essential Nutrients
  - Role in Plant Development
  - Origins of Forest Nutrition Research
- IFTNC: The First Decades
  - A Blank Slate
  - Nutrition & Forest Productivity
  - Diagnostic Tool Development
- Current Nutrient Research
  - Applying Lessons from the Past
  - Future Forest Productivity Study
- The Future of Nutrient Monitoring

Plant Essential Nutrients & Primary Source

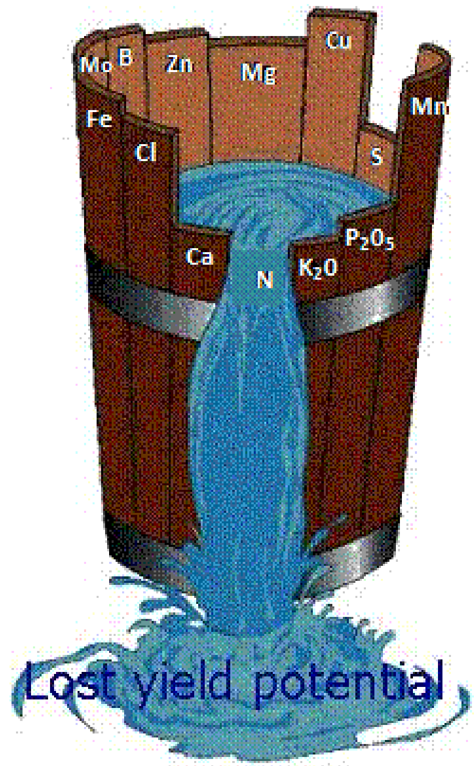
Macronutrients (<100 ppm)
- Nitrogen - Atmosphere
- Phosphorus - Rocks
- Potassium - Rocks
- Sulfur – Atmos., Rocks
- Calcium - Rocks
- Magnesium – Rocks

Micronutrients (<100 ppm)
- Boron - Rocks
- Copper - Rocks
- Zinc - Rocks
- Iron - Rocks

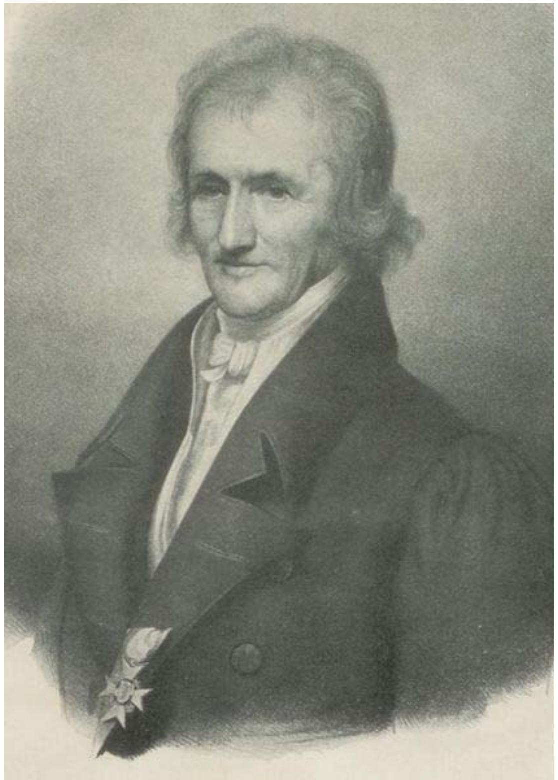


Role of Soil Nutrients in Plant Growth

- **N** – Growth proteins
- **P / S / Mg / Cu / Fe** – Photosynthesis
- **K** – Water regulation
- **Ca / B** – Nutrient transport
- **Zn** – Enzymatic production / DNA transcription



Founders of Modern Forest Nutrition Research

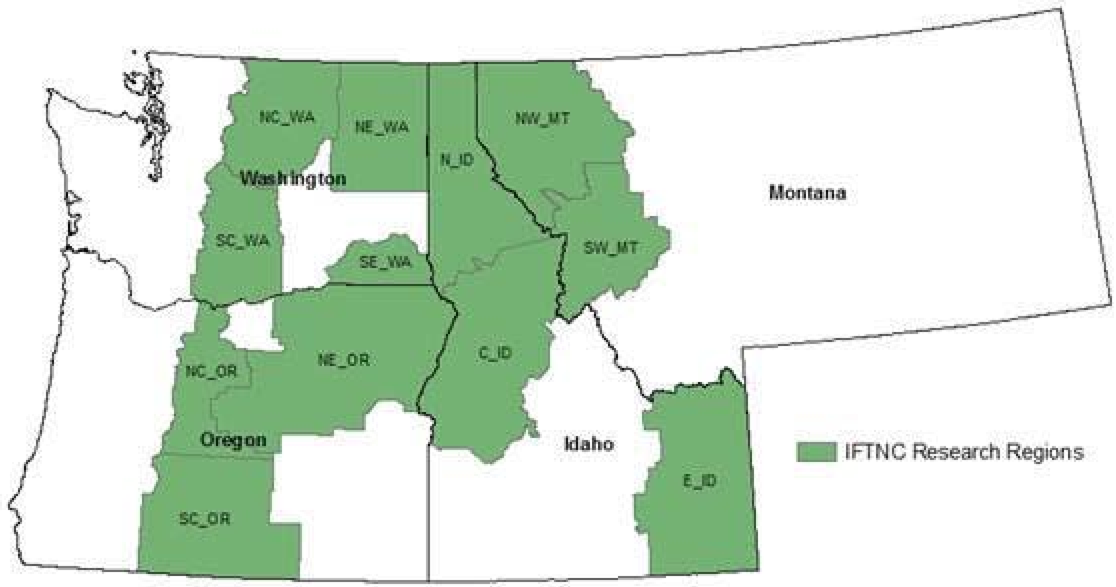


Johann Heinrich Cotta (1763-1844)
Est. 1811 - Royal Saxon Forestry Academy

Karl Leberecht Krutzsch (1772-1852)
Rock and Soil Science
for Forestry and Agriculture - 1827

Inland Northwest: A Blank Slate

- IFTNC established ~ 30 yrs after forest soil research began in earnest within the US



Early Objectives of IFTNC

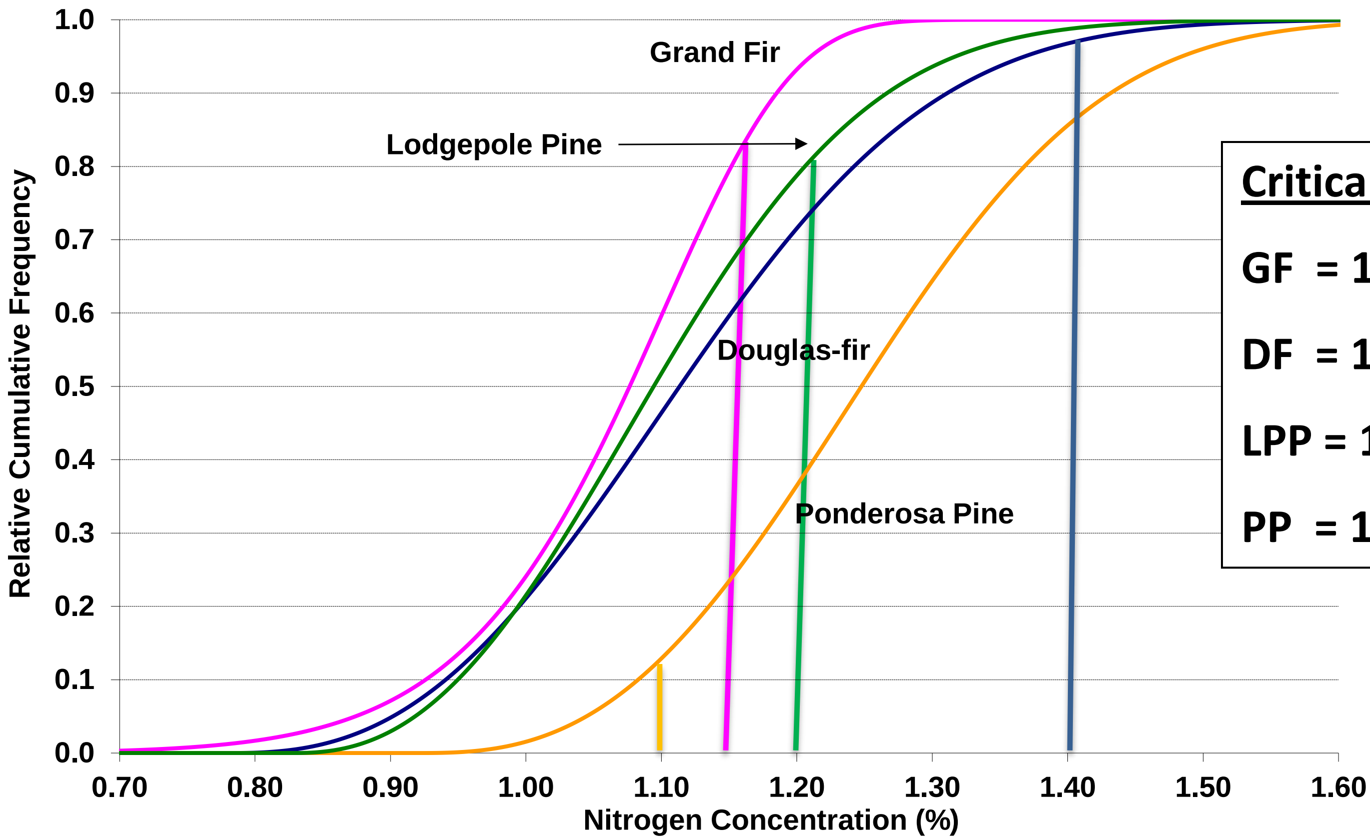
- Define species nutrient limitations
- Define soil-site nutrient status
- Define site type effects on forest health and productivity
- Develop diagnostic tools for rapid site assessment

Nutrient Research: The First Decades

- Began with field fertilization trials in the 80s
- Soils collected to identify native fertility
- Foliage analyzed for critical levels
- Fertilizer effect on soil/foliage/growth measured

Site Nutrient Limitations by Species

Similar deficiencies for S, lesser for B



Critical Levels

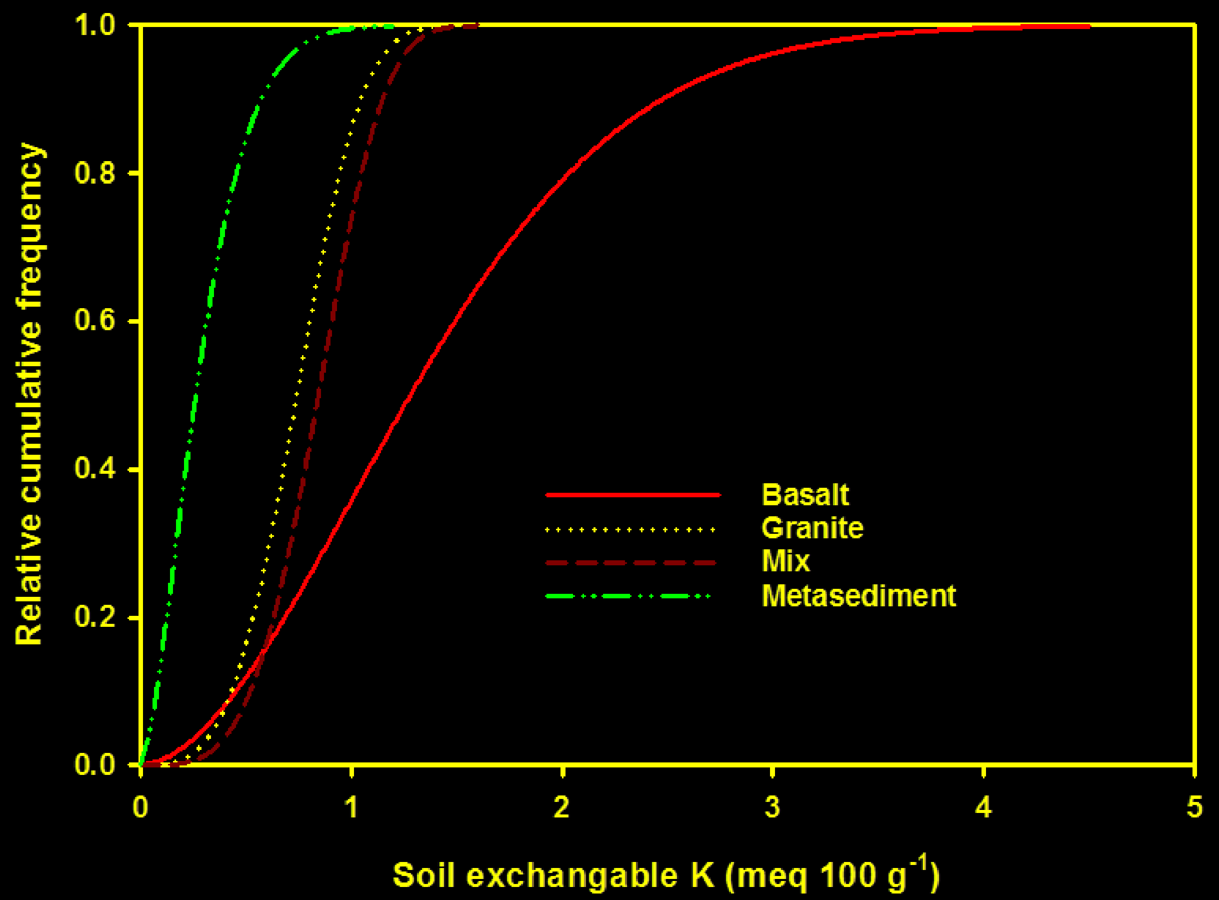
GF = 1.15

DF = 1.40

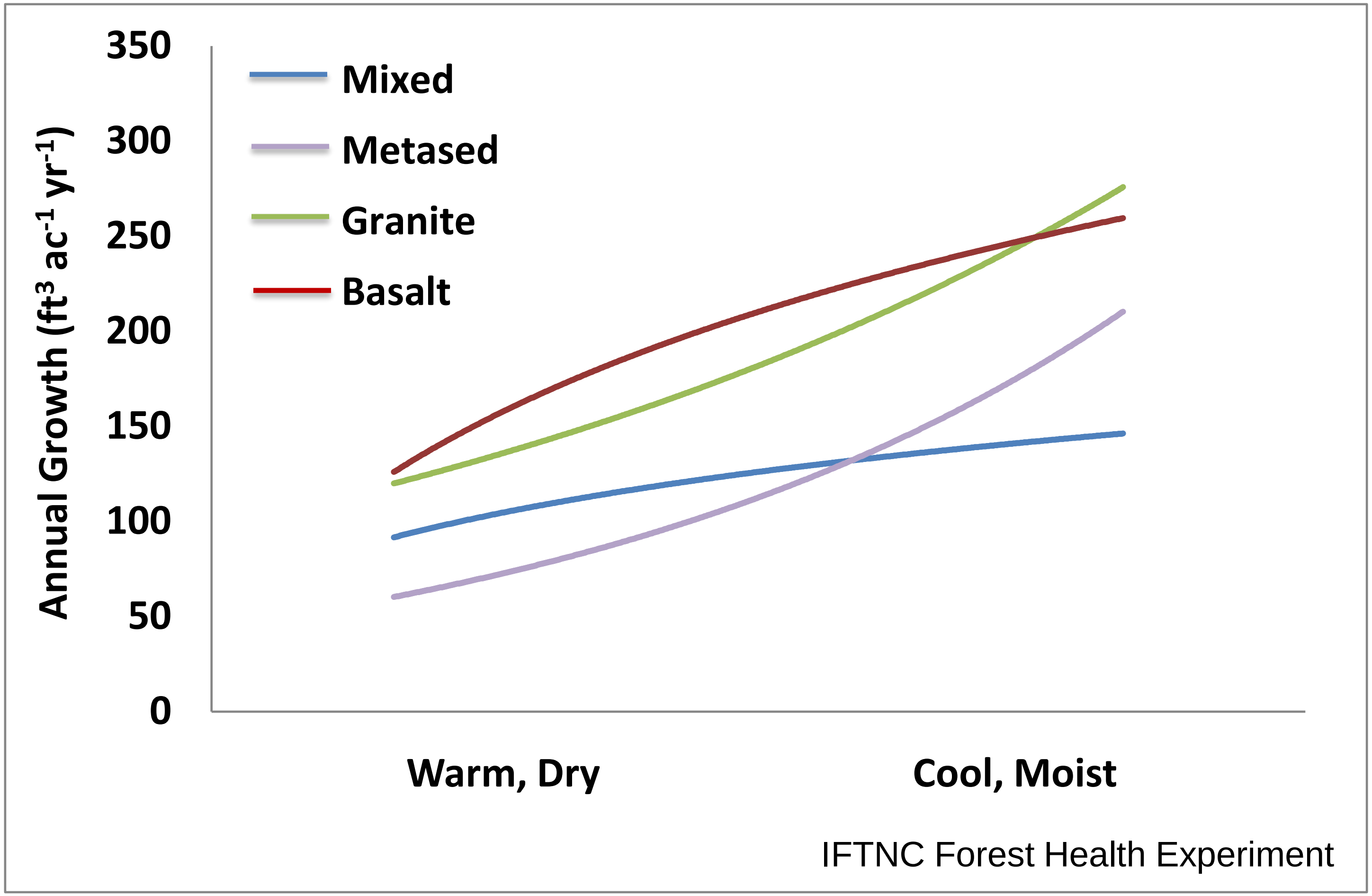
LPP = 1.20

PP = 1.10

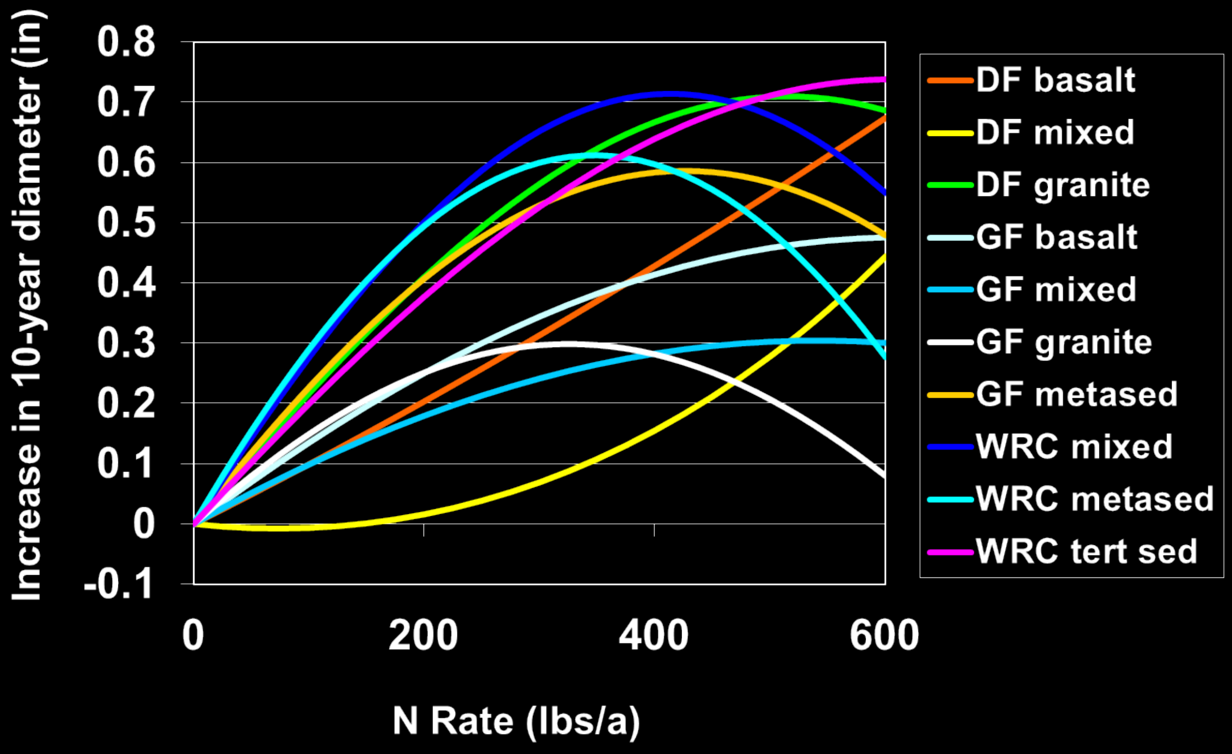
Soil Nutrient Richness by Rock Type



Site Type & Forest Growth

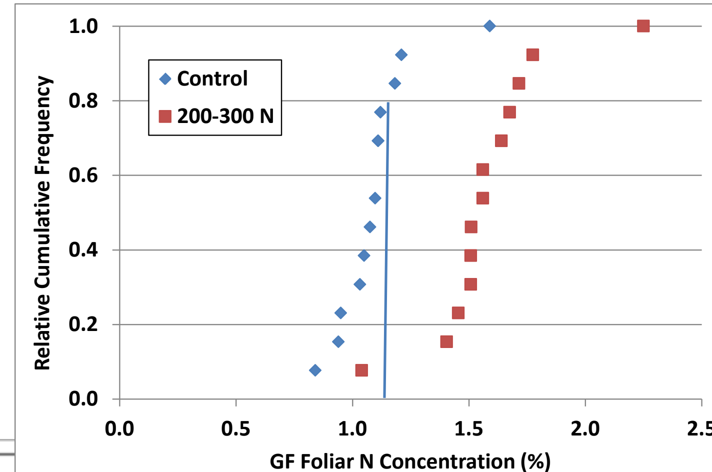


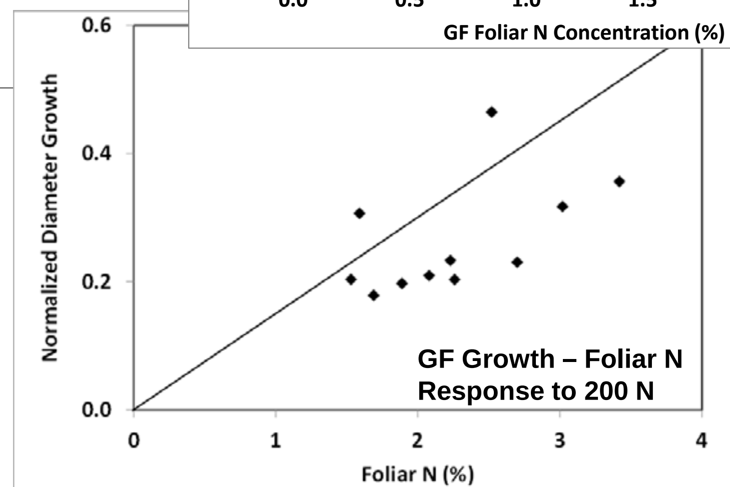
Site Type – Species Response to N

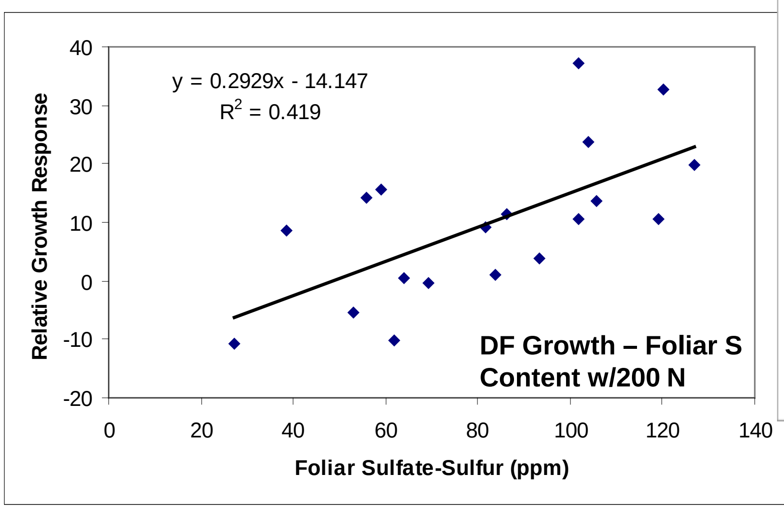


The Beginning of a Diagnostic Disconnect

- Foliar nutrient concentrations usually respond to nutrient amendments
- Foliar nutrition shows weak, but positive correlation with growth response

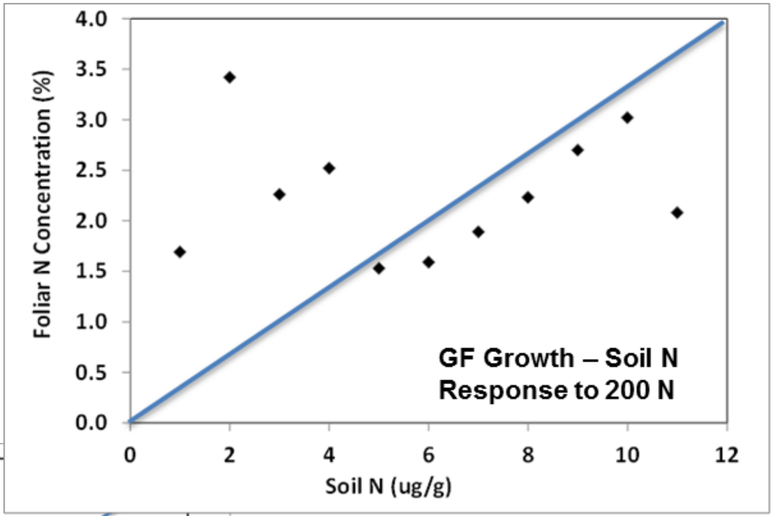


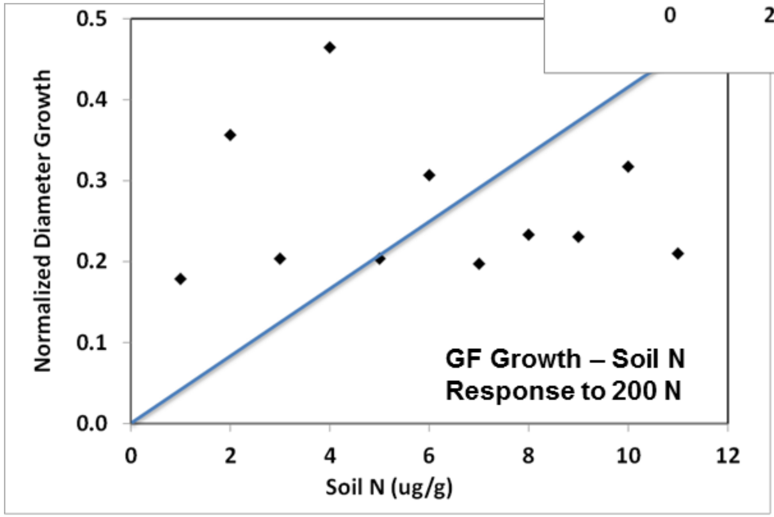




The Great Disconnect

- Standard soil chemical tests show:
  - Very weak correlation with foliar response
  - No correlation with growth response



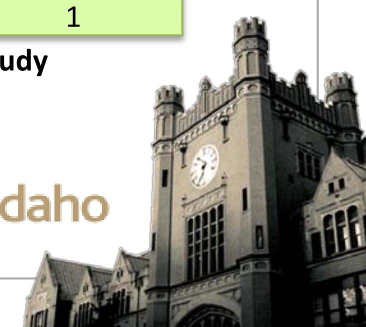


Why the Soil Diagnostic Disconnect?

- Mechanistic
  - Sampling intensity too low
  - Not enough resources, both time and monetary, to capture soil variability
- Environmental
  - Yr from harvest, physiographic conditions will create unique soil environments not comparable across site types (or even within)

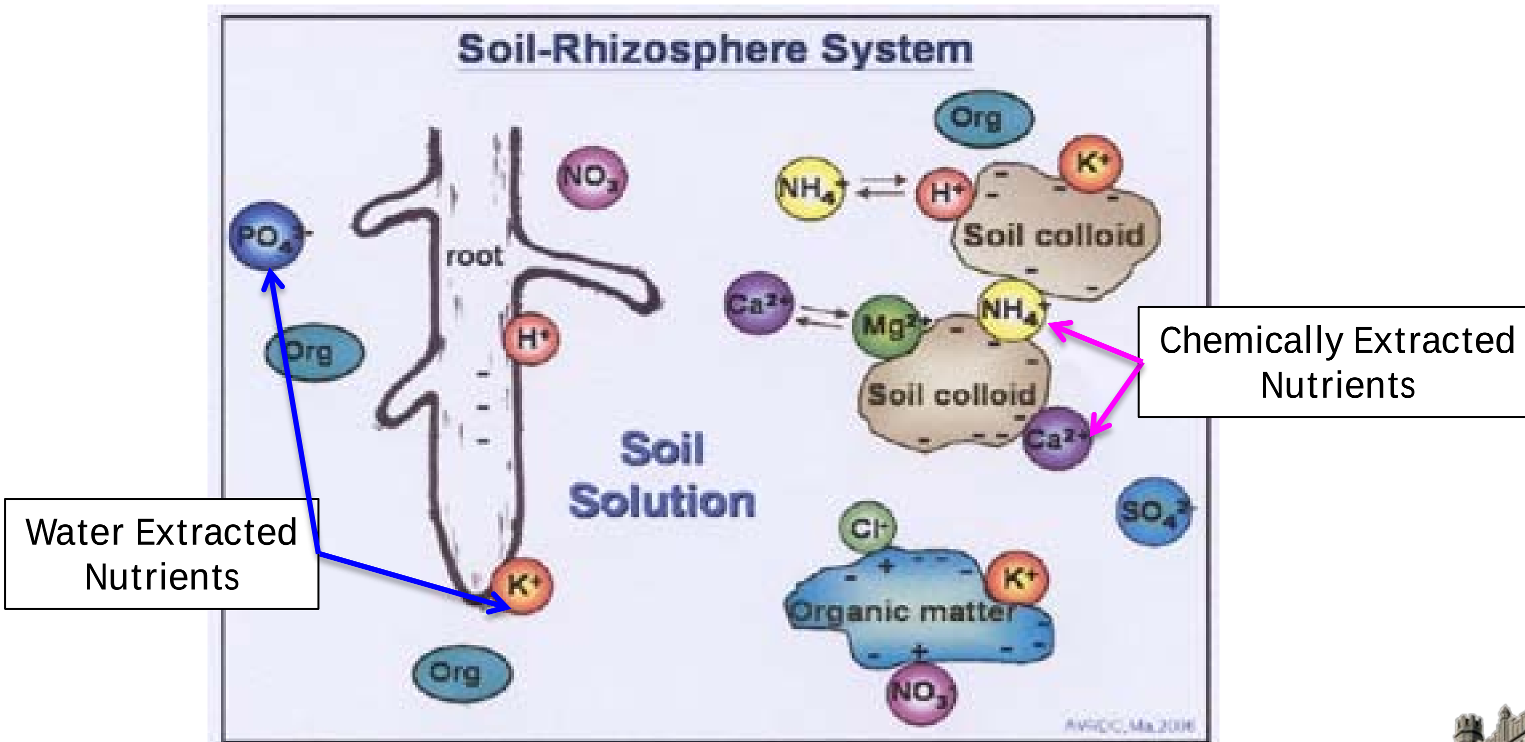
	Required Sample Size @ 10% Error w/10% C.I.		
Soil Nutrient	**Mature Forest**	**Clearcut**	**Clearcut w/Fert**
Mineralizable N	11	50	10
NO_3	3	1	3
NH_4	156	21	60
Available P	30	36	11
Available K	4	11	67
SO_4	40	59	141
Available Boron	35	18	46
Ca	120	116	1
Mg	18	81	1
K	3	13	53
Na	13	13	1
Mn	88	28	67
Zn	62	4	17
Cu	3	86	77
Fe	2	81	7
Organic Matter	9	14	16
pH	1	1	1

Source: Rye on Ham Nutrient Mitigation Study



Is there a better way?

- Nutrient Pool or Nutrient Flux?



Not Ready to Abandon Soil Diagnostics

- Turned focus to Ion Exchange Resins
- Captures nutrients moving through soil solution
- An index of nutrient bioavailability

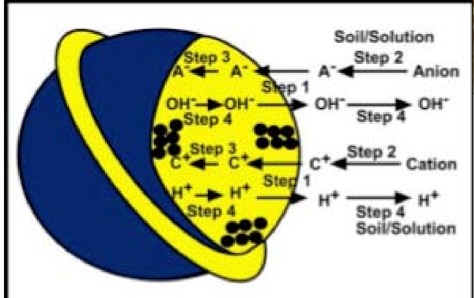


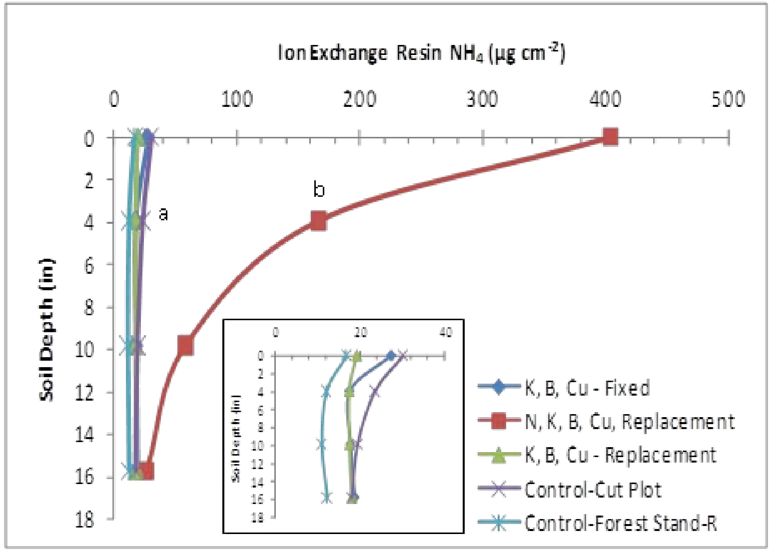
Figure 2
Illustration of a PST-1 resin capsule with individual resin beads containing either positive or negative charges showing steps associated with ion adsorption.

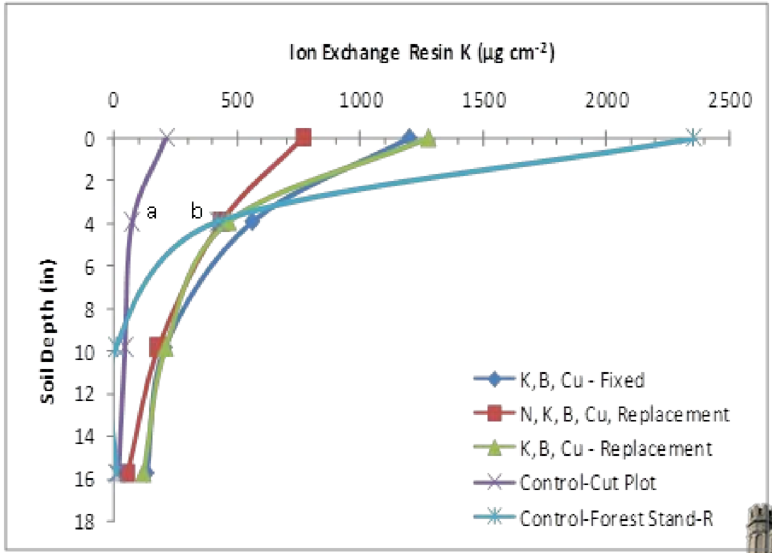
The Beginning of IER Research

- Hybrid Approach
  - Traditional soil pits
  - Installed resin capsules to rooting depth or 100 cm
  - Backfilled pit and returned 1 yr later
  - Exhumed IERs and collected soil samples for correlation

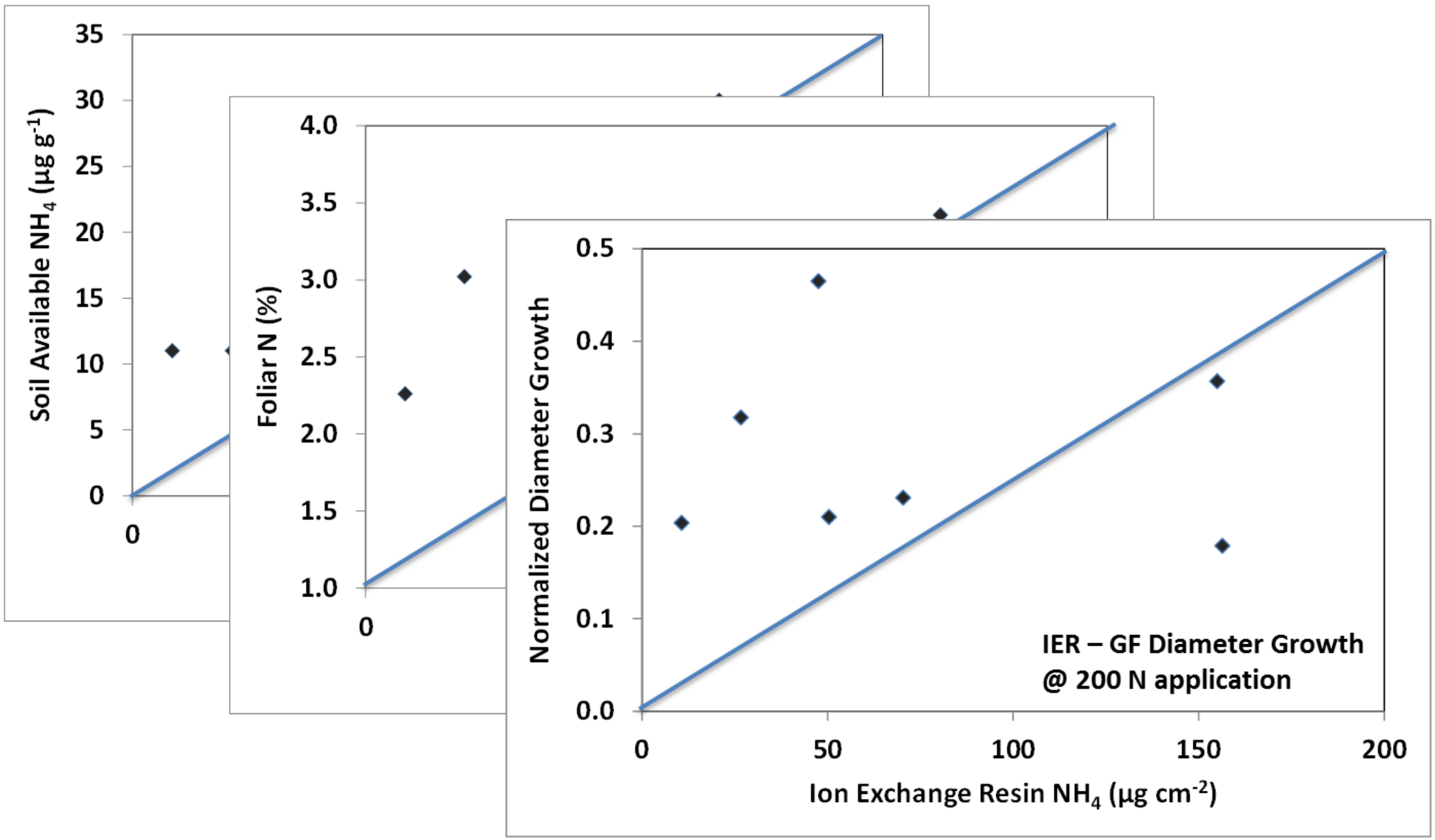
Early Results
Nutrient Flux Assessment

- Objective
  - Detect treatment application
  - Define sampling depth





Early Results
IER – Soil - Foliar Relationships



To Punt or Not to Punt?

- Remember our Hybrid Approach?

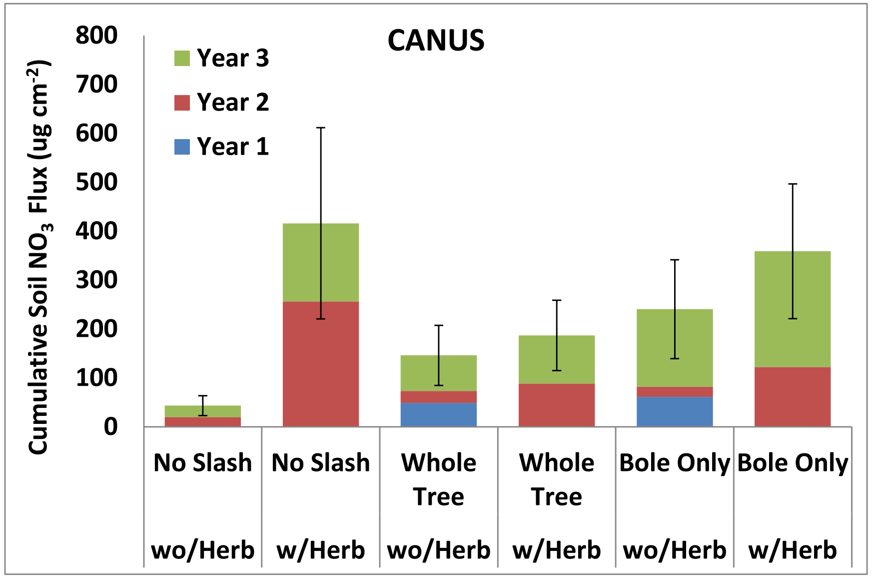
	Required Sample Size @ 10% Error w/10% C.I.		
IER Nutrient	**Mature**	**Whole Tree**	**Bole Only**
NO_3	2	308	429
NH_4	6	15	4
P	108	57	50
K	104	199	176
SO_4	34	182	3
B	132	93	131
Ca	115	87	7
Mg	148	99	89
Na	12	125	50
Mn	119	99	116
Zn	73	56	95
Cu	149	87	90
Fe	42	94	89

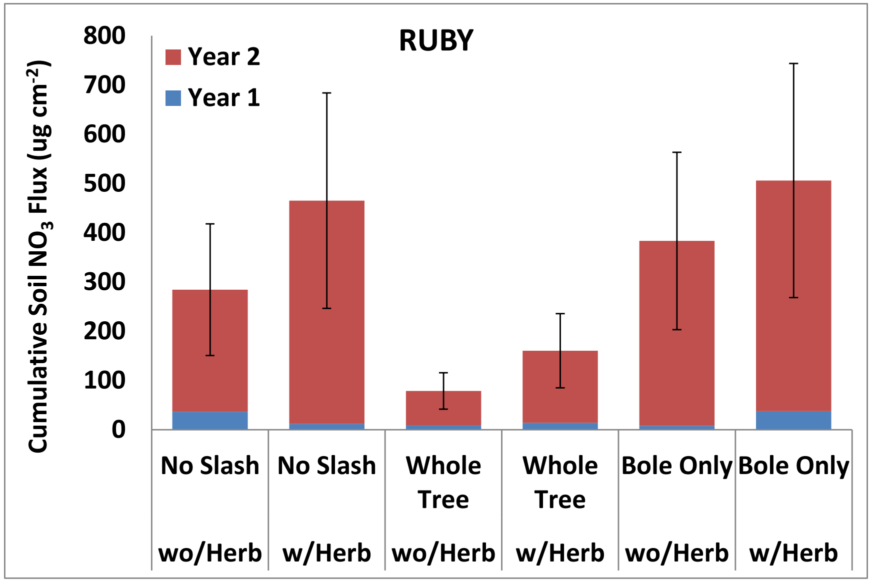
Complete Random
vs.
Stratified Random

Stratified Sampling Approach

- Last Approach:
  - Increased sample size
  - Placed IERs in soil locations reflecting mean treatment effect
  - Limited to surface horizon
  - Reduced cost by installing many IERs within treatment, but composited for analysis

Preliminary FFP – IER Results





Annual Reassessment

- Build 5 yr seedling growth dataset on FFP sites
- Correlate IER cumulative nutrient flux with growth response
- Assess strength of IER to diagnose treatment affect

The Future of Nutrient Diagnostics

- Foliar diagnostics will always be a tool in our silviculture kit
- Soil chemical diagnostics uncertain
- Perhaps shift focus to soil organic matter/carbon
- May need to rely on parent material as a proxy for soil chemistry