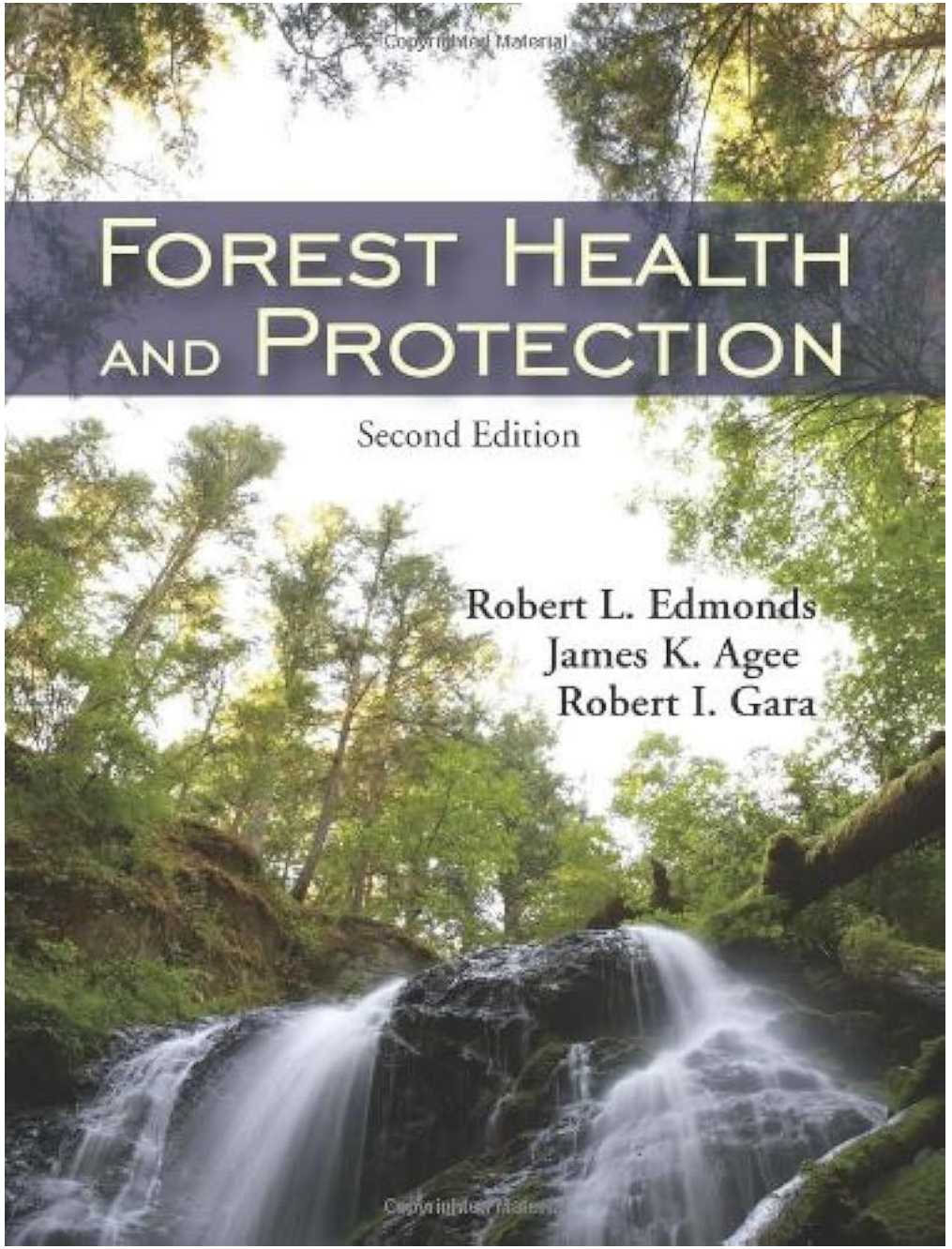

Course in Forest Protection
Master of Science Level
2023-2024

PhD. Dr. Zana Abubakr Ahmed Forest Ecophysiology

Nutrient Deficiencies

- ✓ Sixteen nutrient elements are required for plant growth .
- ✓ One can remember the 10 major elements required through the mnemonic CHOPKNSCaFeMg (pronounced "see Hopkin's cafe mighty good"), which stands for carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulfur, calcium, iron, and magnesium.
- ✓ along with concentrations in foliage typical of most higher plants. It should be recognized, however, that there is considerable variability among species.
- ✓ Note that some are classified as macronutrients, like N, P, K, Ca, Mg, and S; others are micronutrients that are required in much lower concentrations, like Fe, Cu, Zn, B, Mn, Mo, and Cl. Nickel, Si, Na, Co, and Se may also be beneficial.

- ✓ Nutrient elements may be deficient, optimal, or toxic in plant tissues and each element has its own typical range.
- ✓ for example, N concentrations range from 0.8% to 3.0% with an optimum at 1.5% .
- ✓ Foliar analysis may be required to diagnose problems, especially if more than one nutrient is involved.
- ✓ Most nutrient deficiencies show typical symptoms that can be used for initial

Table Typical Concentrations of Essential Elements in Foliage Necessary for Healthy Plants

Element	Concentration in dry mass (ppm)
Macronutrients	
Nitrogen (N)	15,000 (1.5%)
Phosphorus (P)	2,000
Potassium (K)	10,000
Magnesium (Mg)	2,000
Calcium (Ca)	5,000
Sulfur (S)	1,000
Oxygen (0)	450,000
Carbon (C)	450,000
Hydrogen (H)	60,000
Micronutrients	
Iron (Fe)	100
Zinc (Zn)	100
Copper (Cu)	6 50
Manganese (Mn)	0.1
Molybdenum (Mo) Boron (B)	20
Chlorine (CI)	100

- ✓ Nitrogen deficiency is typically exhibited on poor, young soils, particularly on soils formed after recent deglaciation. Phosphorus deficiency typically occurs in areas with very old soils.
- ✓ Potassium, Ca, and Mg deficiencies are rarer.
- ✓ Trace element deficiencies are common on older soils.
- ✓ Most elemental deficiencies can be easily corrected with application of fertilizers.
- ✓ Nitrogen is applied in the form of urea (NH_2CONH_2), NH_4N0_3, or $(NH_4)2S0_4$; phosphorus is applied as rock phosphate or superphosphate; Mg is applied as Epsom salts or $MgS0_4$.
- ✓ The nutritional status of a tree can alter its response to pathogens, particularly those causing root diseases, or insect attack.
- ✓ Seedlings grown with too much N often are spindly, with very succulent tissue that is very susceptible to damping-off fungi and frost damage.
- ✓ Nursery managers may limit fertilization in early growth to reduce susceptibility to damping-off and cause seedlings to harden-off earlier.

Major Functions of Essential Elements in Plants

Macronutrients

Nitrogen (N) Important component of proteins, enzymes, nucleic acids, and chlorophyll. Required in relatively large amounts.

Phosphorus (P) Component of high-energy phosphate bonds of adenosine triphosphate (ATP) responsible for energy transfer in biochemical systems; also involved with RNA and DNA, which mediate protein synthesis and transfer of genetic information.

Potassium (K) Activator of many enzymes involved with photosynthesis and respiration and maintaining internal osmotic pressure in cells; a very mobile nutrient and is present in high concentrations in plant tissues.

Calcium (Ca) Occurs in middle lamella as calcium pectate; needed during cell division and functioning of cell membranes.

Magnesium (Mg) Important enzyme activator and essential in photosynthesis, respiration, and formation of nucleic acids.

Sulfur (S) Important component of proteins and occurs in the amino acids cysteine, cystine, and methionine.

Micronutrients

Iron (Fe) Involved with enzymes, chlorophyll formation, and respiration.
Copper (Cu) Associated with chloroplasts and proteins and oxidation/reduction enzymes.
Zinc (Zn) Important in the functioning of many enzymes and required to produce the growth regulator indoleacetic acid.
Manganese (Mn) Involved with chloroplast formation and evolution of oxygen in photosynthesis; an enzyme activator.
Boron (B) Involved with nucleic acid synthesis, sugar translocation, respiration, reproduction, and water relations.
Molybdenum (Mo) Involved with nitrate reductase enzyme in nitrogen fixation.
Chlorine (CI) Chloride ion plays a role in cell division and photosynthesis.

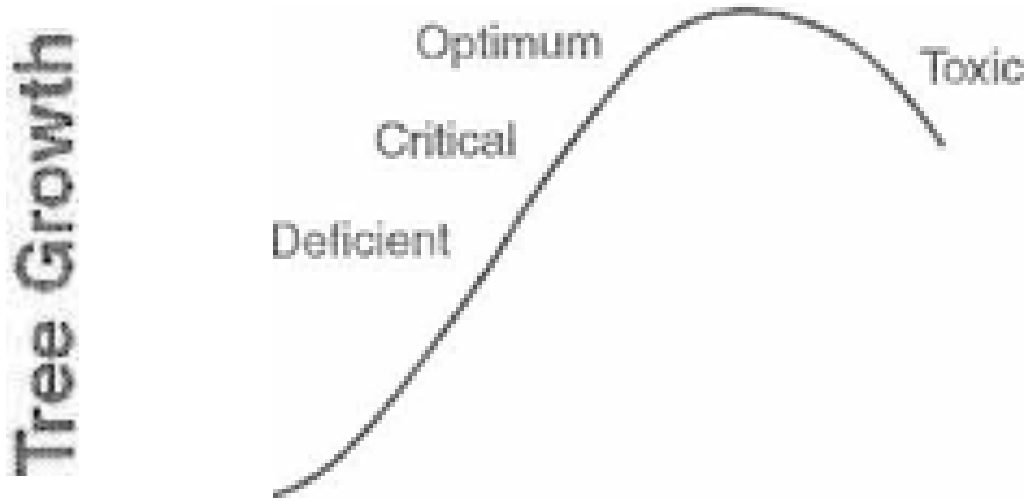

Figure
Nutrient elements may be deficient, optimal, or toxic in plant tissues. (Source: Adapted from Carter 1992)

Typical Nutrient Deficiency Symptoms in Foliage

Macronutrients

Nitrogen (N) Foliage chlorotic or yellow; deficiency first in older needles since N is mobile and moves from older to younger tissues because of demand; in severe deficiency needles small and yellow; most limiting element in soils.
Phosphorus (P) Foliage often red or purple; small, fused needles; deficiency first in older needles; younger foliage green; second only to N as most limiting element in soils.
Potassium (K) Dead areas on edges of leaves or tips of needles; symptoms develop quickly in older tissues because K is so mobile.
Calcium (Ca) Death of terminal bud; deficiency symptoms in youngest tissue because Ca is very immobile.
Magnesium (Mg) Symptoms first in younger tissues; leaves may be cupped, mottled, or have chlorotic spots; old needles on conifer may be yellow with brown tips; basal portion of older needles may be green; youngest needles may be green.
Sulfur (S) Veins on leaves light green; upper needles yellowish; older needles still green; usually not a major problem.

Micronutrients

Iron (Fe) Young leaves chlorotic, but veins remain green; young needles bright yellow; older needles green.
Copper (Cu) Young leaves wilted, but no spotting or chlorosis.
Zinc (Zn) Young needles pale green, then become chlorotic or necrotic.
Manganese (Mn) Spots of dead tissue may develop; leaves become increasingly chlorotic with veins remaining darker green; new leaves are stunted and growth may stop; young needles are pale green or yellowish; in severe deficiency shoot tip may die.
Boron (B) Terminal twigs and root tips fail to elongate normally; stunting; youngest needles bunched, resembling rosettes; foliage gray/green or bronze; stubby roots.
Molybdenum (Mo) Young needles turn pale green or yellow, then brown; rare. Chlorine (CI) None-chloride ion absorbed in far greater quantities than needed.