Non-infectious Agents: Air Pollution Damage
Non-infectious Diseases – Abiotic Diseases

Air pollution damage to woody plants:

• Particulate matter:
  – Combustion of coal, gasoline, oil (lead)
  – Forest and agricultural burning

• Non-photochemically produced pollutants – Primary pollutants
  – Sulfur compounds $\text{SO}_2$
  – Halogen compounds – Fluorides and Chlorides

• Photochemically produced pollutants – Secondary pollutants
  – Ozone
  – PANS – PeroxyacetylNitrate
Non-photochemically produced – Sulfur Compounds

• Point Sources
  – Coal combustion
  – Refineries
  – Smelters – nickel, copper, iron, etc.

• Symptoms
  – On broadleaf plants - interveinal necrosis on leaves
  – On conifers - chlorosis and necrosis from needle tips down
$SO_2 \rightarrow SO_3^{2-}$ (Sulfite)

$SO_3^{2-}$ (Sulfite) $\rightarrow SO_4^{2-}$ (Sulfate)

Sulfite reductase
SO$_2$ damage to birch
SO$_2$ damage to white pine
Usually many different plants in an area will show symptoms
Sulfur Compounds continued..

- Enters stomata – gas dissolved in solution – bisulfite and sulfite
- Toxicity results when SO$_2$ uptake exceeds the plants ability to detoxify sulfite
- Sulfite interferes with enzyme production, amino acid metabolism, chlorophyll levels, ATP production

- What trees are more tolerant? Less tolerant?
  - Sensitive species – pines, birch, aspen
  - Intermediate – oak, fir, hemlock, maples
  - Tolerant – cedar, linden
Smelterville, Idaho
Locations of past ecological disasters due to $\text{SO}_2$

- Copper Basin, Tennessee
- Sudbury, Ontario
- Wa Wa, Ontario
HF – Hydrogen Fluorides

• Point Sources:
  – Aluminum production
  – Steel production
  – Phosphate fertilizer production
  – Brick manufacturing

• Symptoms:
  – Chlorosis at leaf or needle margins
  – Necrosis at margins
Flourine damage to birch
Flourine damage to Ponderosa Pine
HFA

Aluminum production

$$3\text{Al}_2\text{O}_3 + 4\text{C} + 2\text{Na} \rightarrow \text{AlF}_6$$

$$4\text{Al}_2 + \text{CO} + \text{CO}_2 + 2\text{Na}_2\text{CO}_3 + 6\text{F}_2$$

Fertilizer production

$$\text{Ca}_{10}\text{F}_2(\text{PO}_4)_6 + 7\text{H}_2\text{SO}_4 + 3\text{H}_2\text{O} \rightarrow$$

$$3\text{Ca}_3\text{H}_4(\text{PO}_4)_2 + \text{HFA} + \text{H}_2\text{O} + 7\text{Ca}_3\text{SO}_4$$
HF – Hydrogen Fluorides

- Fluorides enter stomata or exterior plant surfaces
- Mobile in vascular system
- Accumulate in tissues
- Affects cell metabolism
- Sensitive – Douglas-fir, pines, gladiolus
- Intermediate - aspen, maple, fir, spruce
- Tolerant – birch, cedar, oak, juniper, locust
Ozone – $0_3$

$\text{NO}_2 + \text{light} \rightarrow \text{NO} + O$

$O + O_2 \rightarrow O_3$

$\text{NO} + O_2 \rightarrow \text{NO}_3$

$\text{NO}_3 + O_2 \rightarrow \text{NO}_2 + O_3$
Ozone damage
Ozone damage to white pine
Ozone – $0_3$

- Point Sources:
  - Auto exhaust
  - Industrial use of fuels
- Enters stomata
- Dissolved in moisture on cell surfaces
- Reacts with cellular components
- Reaction products – super oxide, hydrogen peroxide
- Alters function of plasma membrane and organelle membranes
- Prevents enzyme production; DNA, RNA and protein production
Ozone – $0_3$

- **Symptoms:**
  - broadleaves - stippling on leaf surface
  - conifers – tips of needles have chlorosis followed by necrosis

- **Sensitive** – white pine, other pines, ash, aspen, white oak
- **Intermediate** – box elder, pin oak, rhododendron
- **Tolerant** – locust, fir, cedar

- **Bioindicators** – very sensitive
  - black cherry, blackberry (2nd year canes), milkweed, green ash, white ash.
PANS – Peroxyacetylnitrate

- NO + hydrocarbons: C-C-C-C-C-C-O-NO$_2$
- Symptoms – stippling on bottom of leaf
- Affects spongy mesophyll cells
- Early damage is on lower leaf surface but high concentrations affect top leaf surface as well
- Phytotoxic to cells causing cell death
\[ \text{NO}_2 \xrightarrow{\text{uv}} \text{NO} + \text{O} \]

Hydrocarbons added

\[ \text{C-C-C-C-C-C-C-C-C} = \text{O} - \text{NO}_2 \]

PAN - peroxyacetyl nitrate
Control for Air Pollutants

• Eliminate the pollutant
• Use resistant varieties
• Forecast air pollution episodes – curtail emissions as levels get higher