



2003 AFCEE Technology Transfer Workshop

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Promoting Readiness through Environmental Stewardship

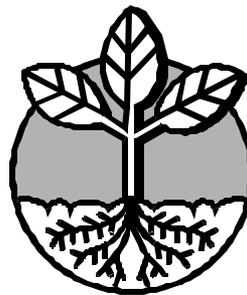
Phytoremediation for Air Force Sites

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Definition

- Phytoremediation is “...*direct use of living plants for in situ remediation of...*”¹
- Plant roots generally should contact the contaminant
- Living plants may serve as host for another living organism that performs remediation
- Six sub-fields¹ (definitions continued)



1. US EPA, 1999. Phytoremediation Resource Guide, EPA 542-B-99-003



Sub-fields^{1,2} - Definitions (concl.)

- Phytostabilization (contain or immobilize)
- Phytoextraction (accumulate within the plant)
- Rhizofiltration (adsorption or precipitation on plant roots)
- Phytodegradation (breakdown by metabolic processes)
- Rhizodegradation (breakdown by yeast, fungi, or bacteria growing on root exudates)
- Phytovolatilization (translocation to atmosphere by plants)
 - US EPA, 1999. Phytoremediation Resource Guide, EPA 542-B-99-003
 - Interstate Technology Regulatory Council. 2001. Technical and Regulatory Guidance Document: Phytotechnology



Remediation Applications

- Organic chemicals (including chlorinated species)
- Pesticides
- Herbicides
- Metals
- Radionuclides
- Explosives



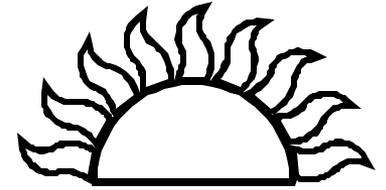
How it Works

- Phytoremediation is based on plant growth, therefore:
 - Employs a complex system
 - Similar to agriculture, forestry, or rangeland
 - Dependent on interactions of climate, plants, soil, contaminants, bacteria, fungi, disease, insects, etc.
- Requires application of many fields of knowledge:
 - Agricultural engineering
 - Soil science
 - Agronomy
 - Hydrology
 - Chemistry
 - Others



Climate Factors

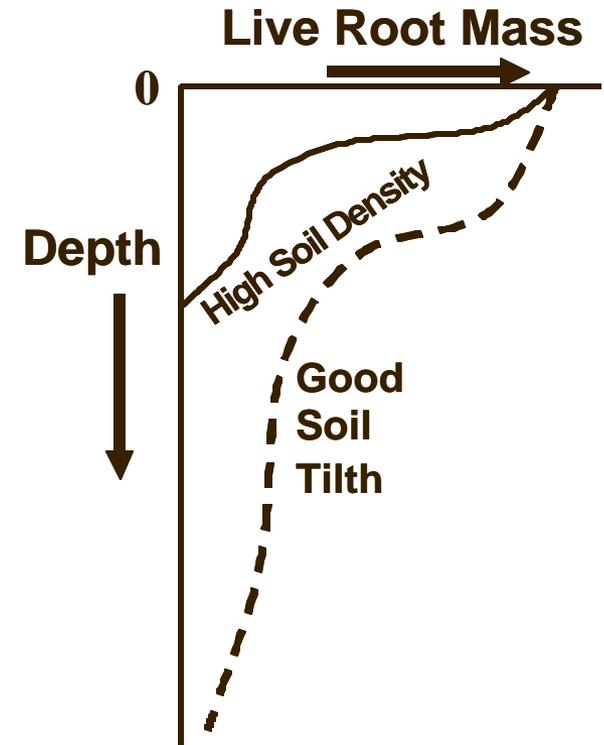
- Solar radiation
- Temperature
- Precipitation
- Dew point and/or relative humidity
- Wind
- Growing season





Plant Factors

- Climate requirements
- Growth rate and size
- Root distribution patterns
- Tap root or fibrous root system
- Root density
- Root strength

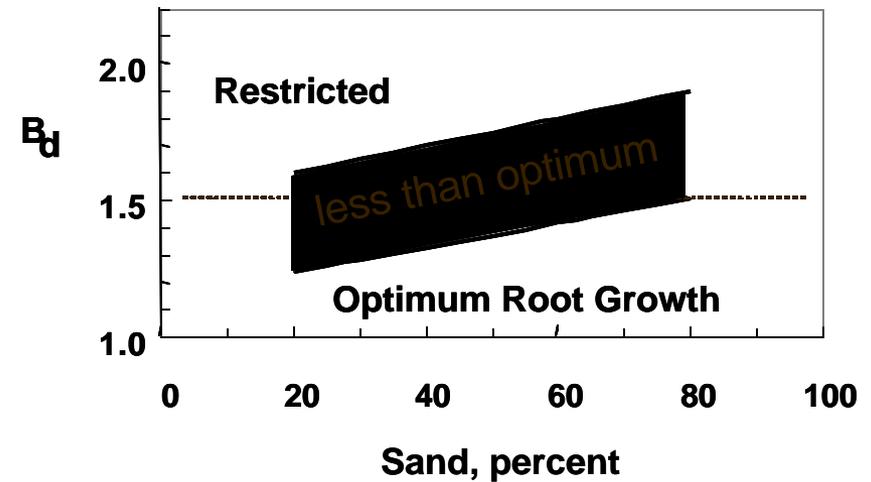




Soil Factors

- pH
- Nutrients
- Humus
- Salinity
- Soil strength controlled by:
 - Soil density
 - Water content
 - Particle size distribution

Effect of soil bulk density B_d , and particle size on root growth¹



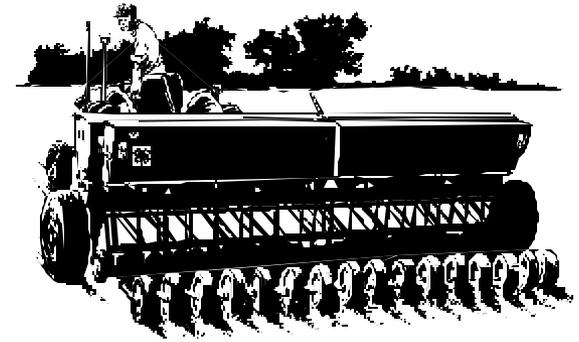
1. From: Sharpley & Williams, 1990, pp. 56-57



Cultural Factors

Availability of:

- Planting machinery
- Harvesting and processing machinery
- Irrigation water
- Seed or transplants





Pros & Cons

Advantages

- Solar energy driven
- Natural
- Self sustaining
- Effective
- Low cost
- Useful for final cleanup of low concentrations

Disadvantages

- Requires large land areas
- Slow process
- May require:
 - Relocation of facilities
 - Soil treatment to provide adequate root environment



Summary

Phytoremediation

- Requires new applications of engineering and science knowledge
- Has excellent potential for use at Air Force sites

