Landfill ET Covers in Wet Climates

Evapotranspirative (ET) Landfill Cover Conference
Denver, CO
March 9 , 2004

Dr. Louis Licht, Ecolotree®, Inc.
Founder and President
Ecolotree.com

Evapotranspirative (ET) Covers

Phytoremediation

A Subset of

Plant-augmented

Bioremediation

What's Phytoremediation?

- the use of plants
- in engineered systems
- to speed contaminant clean up or capture.

Phytoremediation is Agronomy with a twist

Agronomy

- science and economics of crop production
- the management of

Harvested PLANT YIELD

Phytoremediation is Agronomy with a twist

Phytoremediation

- is the science and economics of crop production
- –management of

PLANT FUNCTION

Phytoremediation is Agronomy with a twist

FUNCTIONS :

- Water removal
- Microbe stimulation
- Decomposer stimulation
- Soil stabilization

Phytoremediation is Agronomy with a twist

Phytoremediation FUNCTIONS :

- Water removal
- Microbe stimulation
- Decomposer stimulation
- Soil stabilization

Resulting in

- Pollutant sequestration
- Pollutant uptake
- Pollutant mineralization

Phytoremediation is Agronomy with a twist

Resulting in

- Pollutant sequestration
- Pollutant uptake
- Pollutant mineralization

- Short-term Outcome Being:
- Landfills Leak Less Toxins
- Decreased Contaminant movement into the local Ecosystem
- Decreased Human Population exposure to the toxins

Phytoremediation is Agronomy with a twist

- 50-year Outcome Being:
- Where was the landfill?
- Possible future mine.
- Liability is contained.

ET Covers Mimic Nature's Way

Pioneering plants revegetate old landfills

Historic ET Cover Prototypes

Prototype defined:

- New thinking – never done before
- Original

ET Cover Prototypes

Prototype defined:

- New thinking – never done before
- Original

- **Lakeside Landfill Prototype** served as the first model for the future ET Cover designs in wet climates

Construction debris landfill (Oregon, 1990)

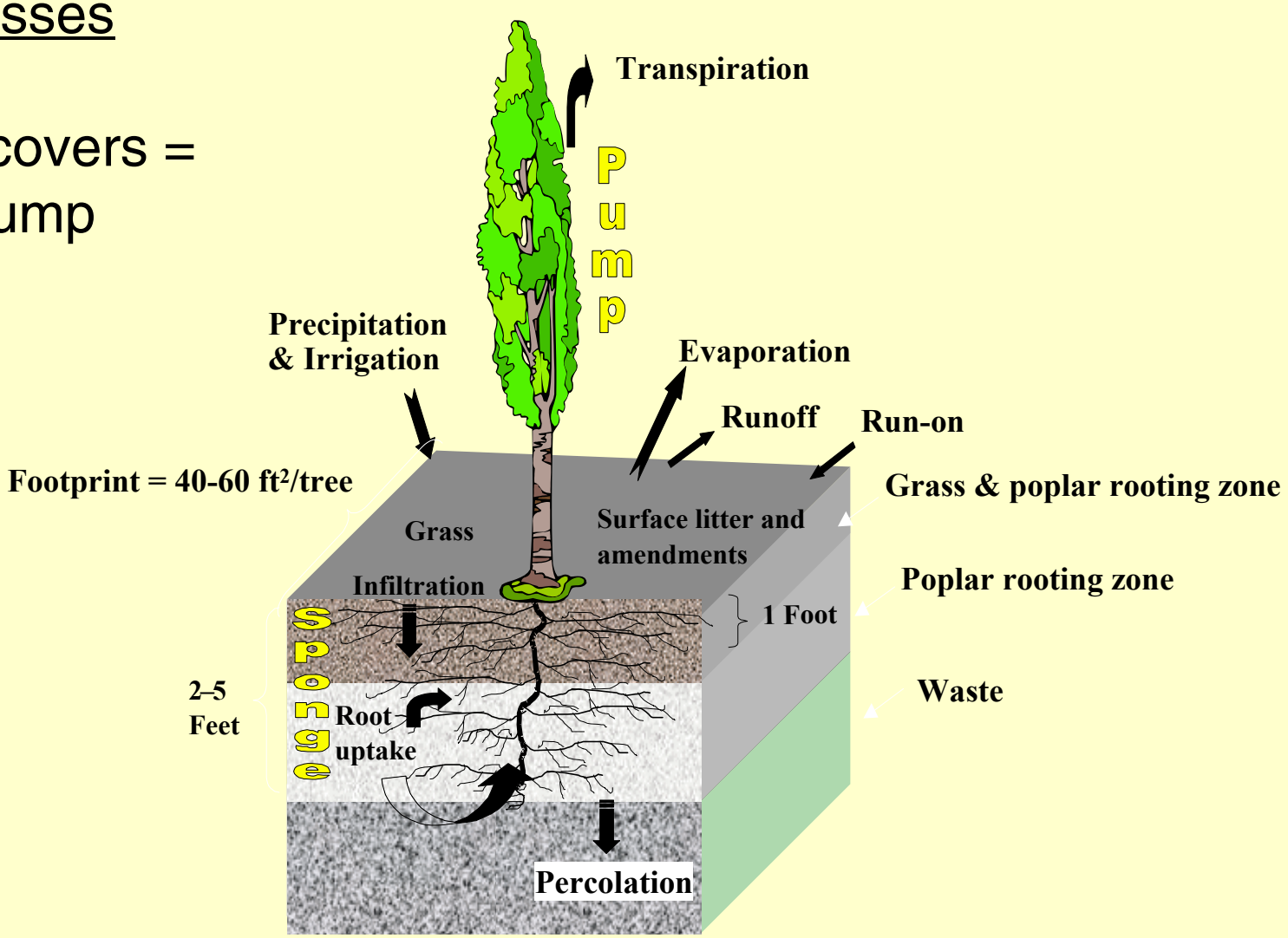
Existing Technology: Prescribed Plastic Landfill Cap ‘Raincoat’

Raincoat Covers makes precipitation into Runoff on landfill

Prototype:
Construction debris landfill (Oregon, 1990)

Major processes

Alternative covers = sponge & pump



Percolation = Initial Moisture + Precipitation + Irrigation + Runon - Final Moisture – Evaporation – Transpiration - Runoff

“Sponge & pump” mechanism

Matches soil Available Water Holding Capacity (AWHC)
&
plant Evapotranspiration (ET) capacity

Planting using Poplar Whips in 42” deep ripped slits

Why Poplar?

1. Research measured 600 lb water/lb stem and yields of 8,000 – 16,000 lb wood stem/acre/year

8-year old poplar trees in Columbia River Basin of Oregon

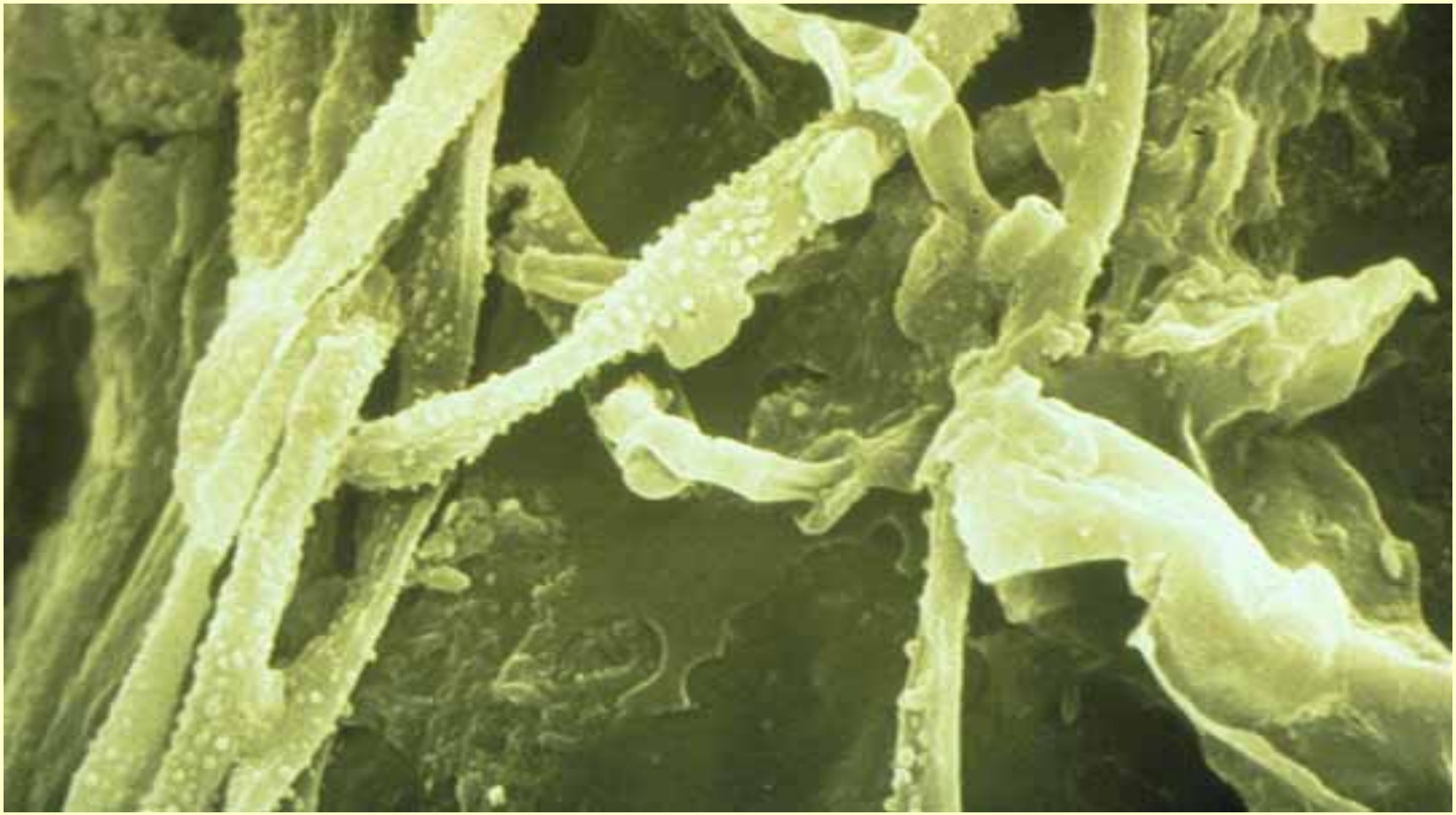
Why poplar?

2. Physiology - Deep, Dense Root Systems are Possible (Phreatophyte)

1.8 m (6 ft) Deep Roots for 5-year Old Hybrid Poplar in Iowa

Why poplar?

3. Ecology – Increased root-associated microbe population that increases pollutant reaction rates



Why poplar?

4. Ecology – Low-oxygen tolerance inferred from root survival below ground watertable during floods

Planting using Poplar Whips in 42” deep ripped slits

Shortly after planting 7,500 hybrid poplar whips (spring 1990)

Success!!! Lakeside Landfill after seven years – significantly less percolation measured!

Lakeside Landfill had no Notices of Violation in 14 years !

One benzene hit in perimeter wells above target in 14 years !

Prototype Research at Lakeside

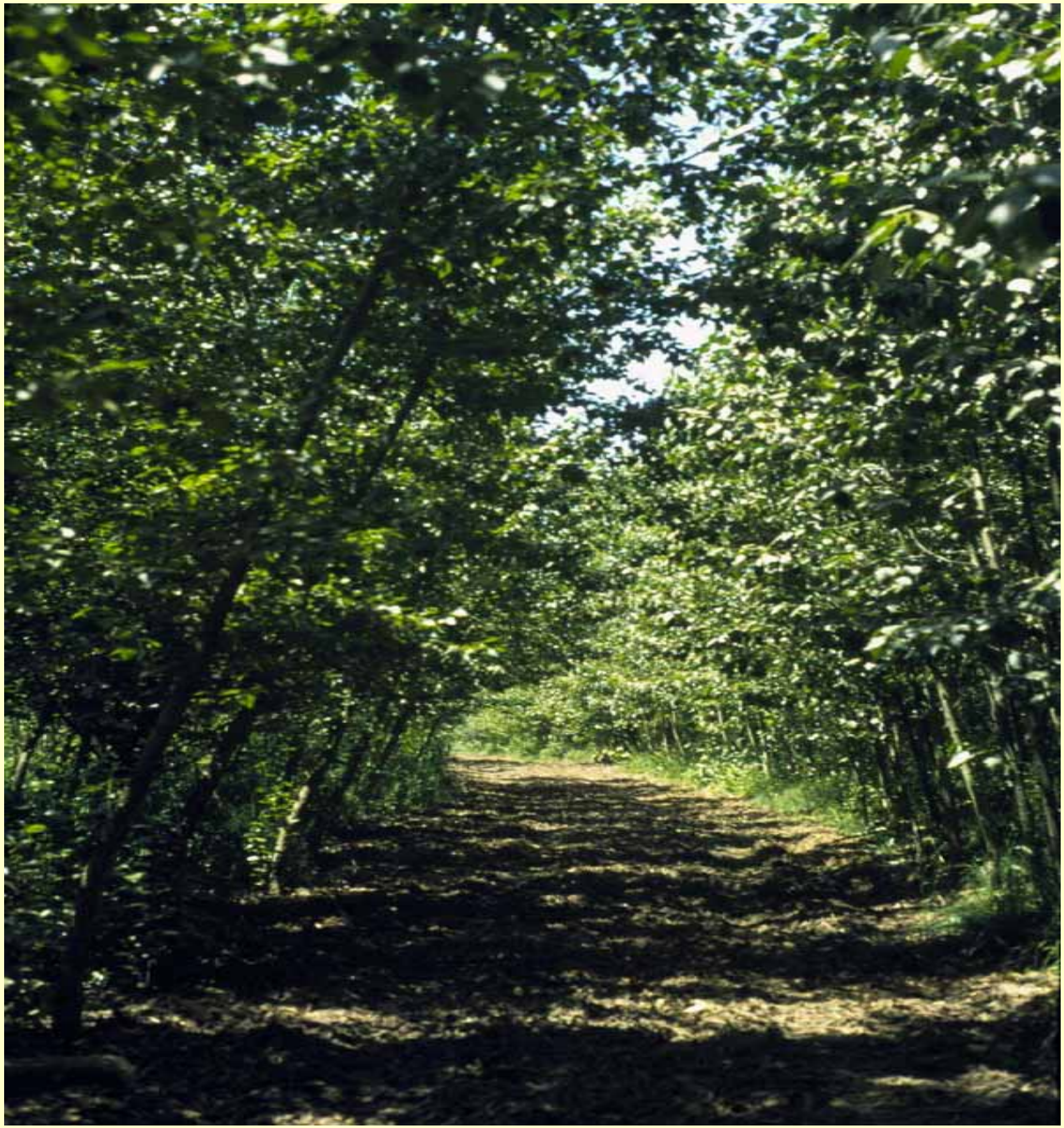
Root-zone depth measurement – 4+ft

Rhizosphere microbe measurement

Conifer interplanting for succession

Lakeside Landfill - Habitat and Ambiance

7 years after planting



Results since 1990

- Received permit for tree cover over remainder of landfill (Oregon DEQ permit #24)
- Tree height = 50-70 feet
- Tree roots growing through entire 4-foot cover
- Soil moisture data suggests superior water management to grass-only cover
- > 30 poplar varieties planted over additional 15 acres

Before - 1990

Lakeside after 7 Years

Tree failure!!! Lakeside Landfill after fourteen growing seasons!

Stresses:

Tree and root wounds (vole, sheep grazing) caused fungal structure breakdown – and trees broke off

Genetics: 50 tree varieties tested, over 30 were not tolerant to stress

Poor fertility, and serious drought stress in summers

Possible gas toxicity

Lakeside Landfill replant plan over ‘mature’ landfill with less gas generation:

Replant with a conifer and poplar blend

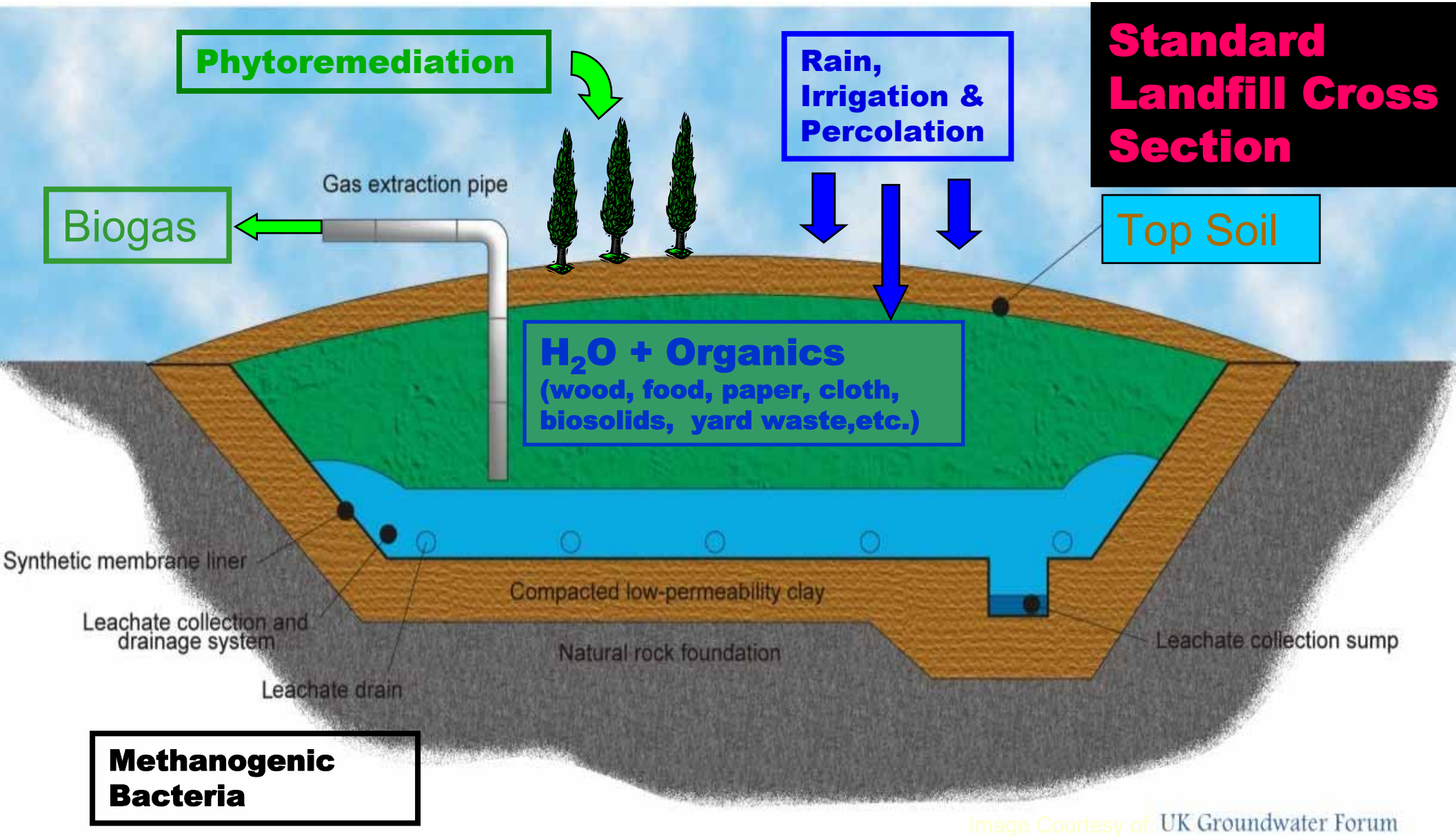
Western Red Cedar and TD Hybrid Poplar at WSU Washington test forest

Erick Miller Aspect Consulting

ET Cover Expansion to 23 Acres

- **Proven species, better agronomy, starter irrigation, no sheep**

Standard Landfill Cross Section



Methanogenic Bacteria

$$C_{68}H_{111}O_{50}N + 16\ H_2O \rightarrow 35\ CH_4 + 33\ CO_2 + NH_3$$

Image Courtesy of: UK Groundwater Forum

Strong Inference

1. If A is True
2. And B is proving to be true

THEN BY STRONG INFERENCE

3. C Has a great chance to be true

Strong Inference

1. And if water is essential to stabilize waste - True
2. If a Subtitle D landfill cap leaks very little water

THEN BY STRONG INFERENCE

3. An impermeable cover will slow landfill stabilization

Strong Inference

1. Plants pump water out of the soil with roots
2. And if plant roots pump ground water faster than rainfall

THEN BY STRONG INFERENCE

3. Roots will dewater the soil

Strong Inference

1. Plant growth uses predictable water to grow a predictable yield.

2. If plant growth uses growing season precipitation and stored soil water

THEN BY STRONG INFERENCE

3. Sufficient plant growth can predictably dewater a ET Cover soil = predictable seepage

Strong Inference

1. And if water is essential to stabilize waste - True
2. If a Subtitle D landfill cap leaks water at predictable rates

THEN BY STRONG INFERENCE

3. Water added through a porous cover will speed landfill stabilization

Strong Inference

1. If water with organic waste stimulates biogas production is True
2. And if a stable landfill begins with all carbon stabilization and degassing

THEN BY STRONG INFERENCE

3. Water addition to waste with gas production is necessary - Biocell

Strong Inference

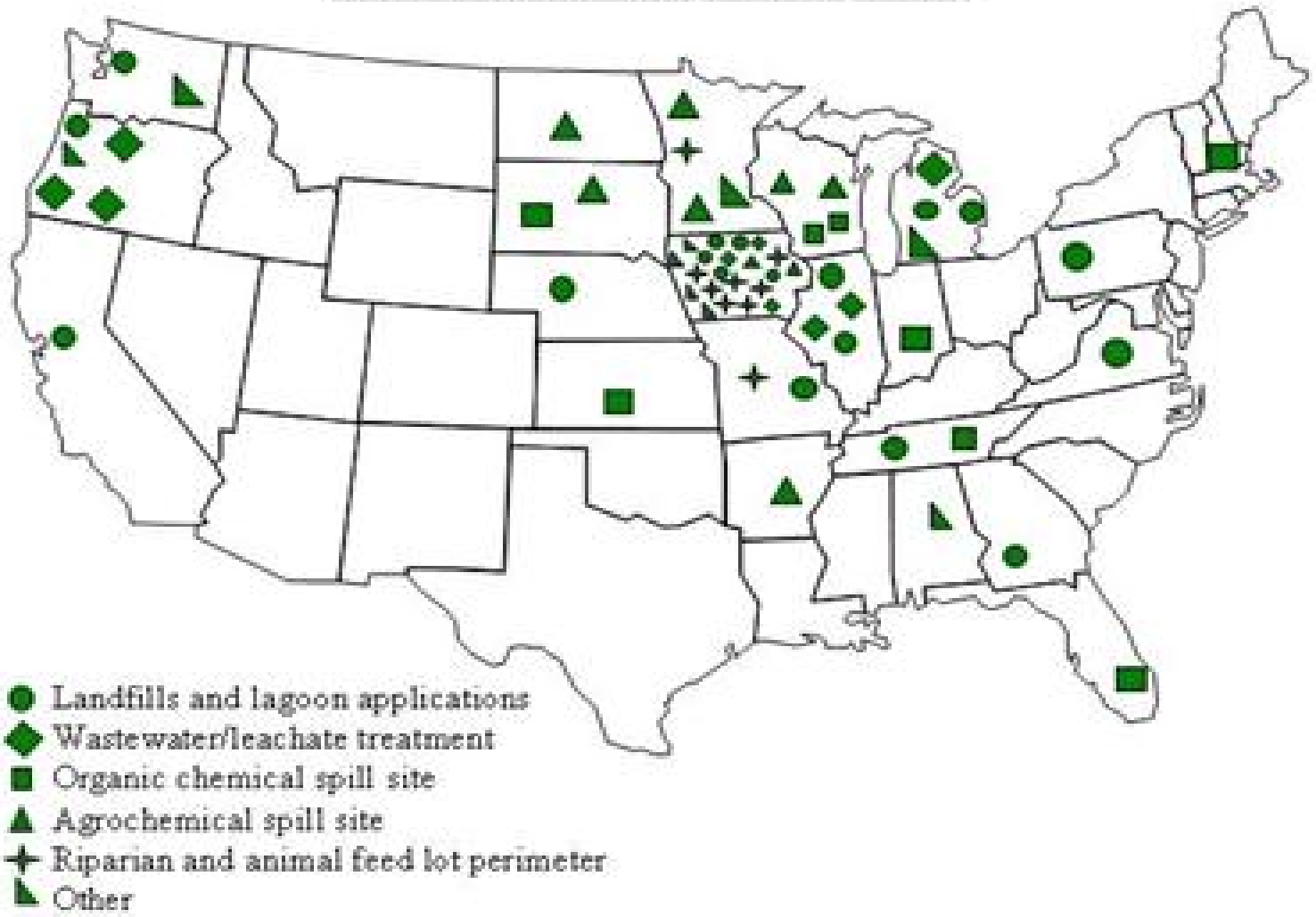
1. If methane oxidation in plant root and soil systems is True

2. And if a soil cover can oxidize methane at the rate landfills leak gas

THEN BY STRONG INFERENCE

3. An ET Cover can let you turn the pumps off 10 – 15 years earlier

Ecolotree Sites (as of July 2003)



Strong Inference is allowing Decommissioned Lagoon Closure using ET Covers

Flushed manure from 5000 sow gestation housing.

Decommissioned Lagoon Closure

- **Decommissioned lagoons have not received manure since 1998**
- **Total surface is 0.7 acres, 15 feet excavated depth**
- **Current NRCS Rule requires ‘clean closure’ excavation of solids.**
- **North Carolina has 1,400 ‘decommissioned’ lagoons**

Decommissioned Lagoon Closure

Planting poplar:

- **two varieties**
- **two age classes**
- **with and without roots.**
- **320 trees on 0.5 acres.**

Decommissioned Lagoon Closure

Planting took one day

Need healthy plants and root systems for "sponge and pump" to work

6-foot deep roots for 5-year old hybrid poplar trees in Iowa

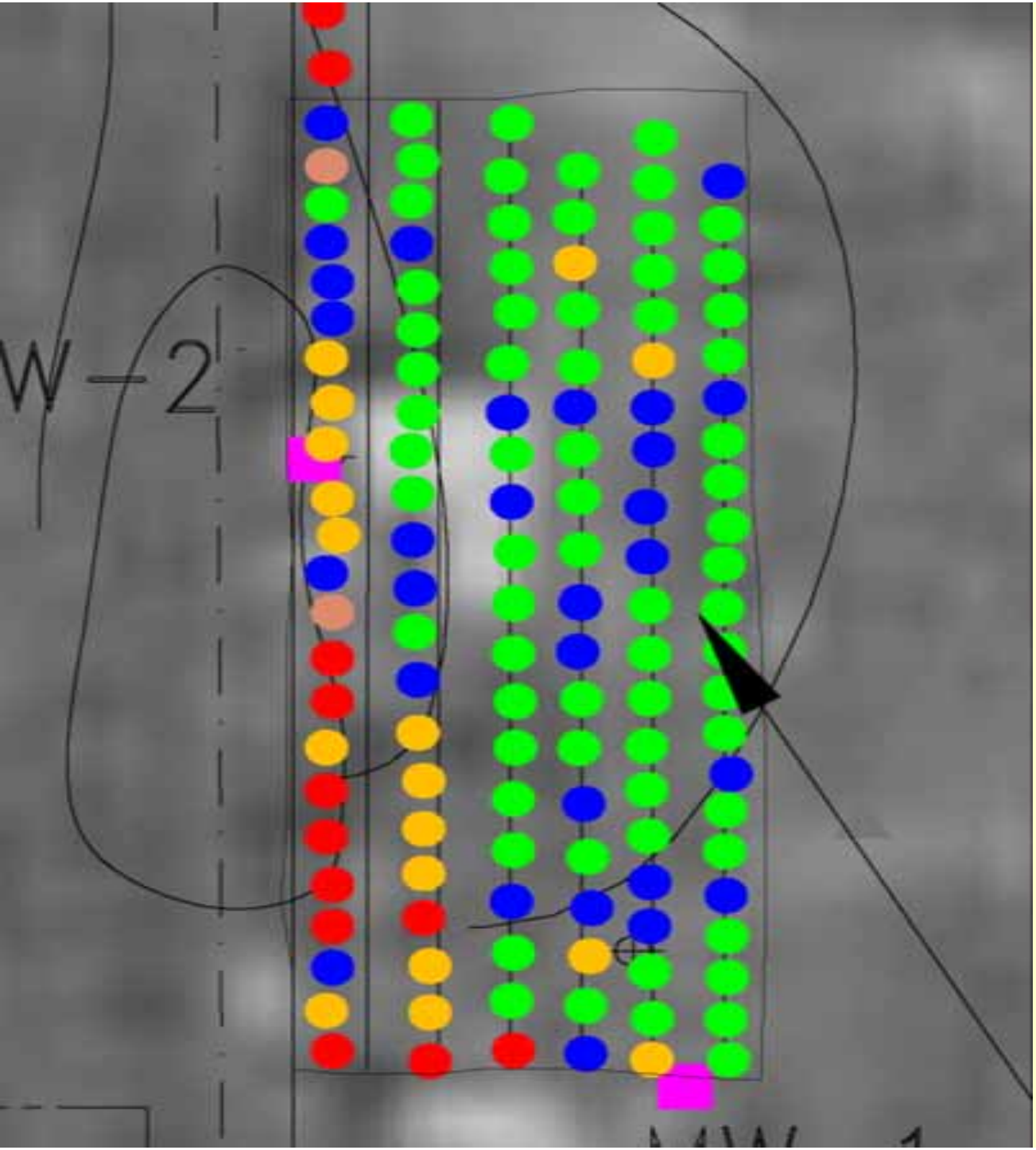
Need healthy plants and root systems for "sponge and pump" to work

Like Agronomic Crops

6-foot deep roots for 5-year old hybrid poplar trees in Iowa

Soil-Covered and Closed Lagoon – December 2003

Following Planting: the ET Cover is ready for March bud break.



We are borrowing the agricultural application of GPS mapped by Archview to monitor performance

Summary

- ET Cover field installations are still few so alternative practices are still being tried – far from a mature science
- ET Covers are not effective for all sites: salty root zones, quick cleanup schedule, no direct ownership, or were regulators require strict percolation equivalence to plastic covers in cool, wet climates.
- ET Cover prototype performance data supplied by university and private owners helps hone agronomic principles

Summary

- ET Cover operators are learning how to prioritize and manage stresses.
- ET Cover will change as pioneering plants give way to diversity and maturity. Accept fact that plant succession is normal.
- ET Cover technology is already being examined for other applications, thus more design and agronomic data is on the way from other sources.

10 ET Cover Myths:

•Predicting future

•2. Clay caps keep their imperviousness once installed properly
•14. Perimeter monitoring is the best way to track problems
•10. ET Covers are difficult to monitor
•Is diversity good, and does it take a long time

•Predicting liability
•18. Neighbors, owners, and insurers want cover 'raincoats'
•17. Landfills becoming bathtubs are bad, and can only be controlled by matching bottom leakage to cover percolation
•2. 30 years post-closure and the pollution potential is gone
•11. 30 years post-closure and the owner's liability is gone
Installation and operation Techniques
•16. Irrigated leachate back on the cover surface is bad and illegal
•7. Trees are unpredictable, blow over, and fragile
•12. ET covers with trees are 'static' installation and operation
•8. Roots can't grow in waste
•4. Trees punch holes in landfill covers
•5. Gas always kills trees
Predicting functions
•6. Methane treatment through ET Covers inconsequential
•9. Gas production and organic breakdown is secondary to a good cover