VEGETATION BASED ASSESSMENT TOOLS FOR LANDFILL LEACHATE ELINEATION AND TREATMENT

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Plants and our Planet

https://www.dreamstime.com

Exposure Biology and the Exposome

Contact

Water

Air

Soil - Food

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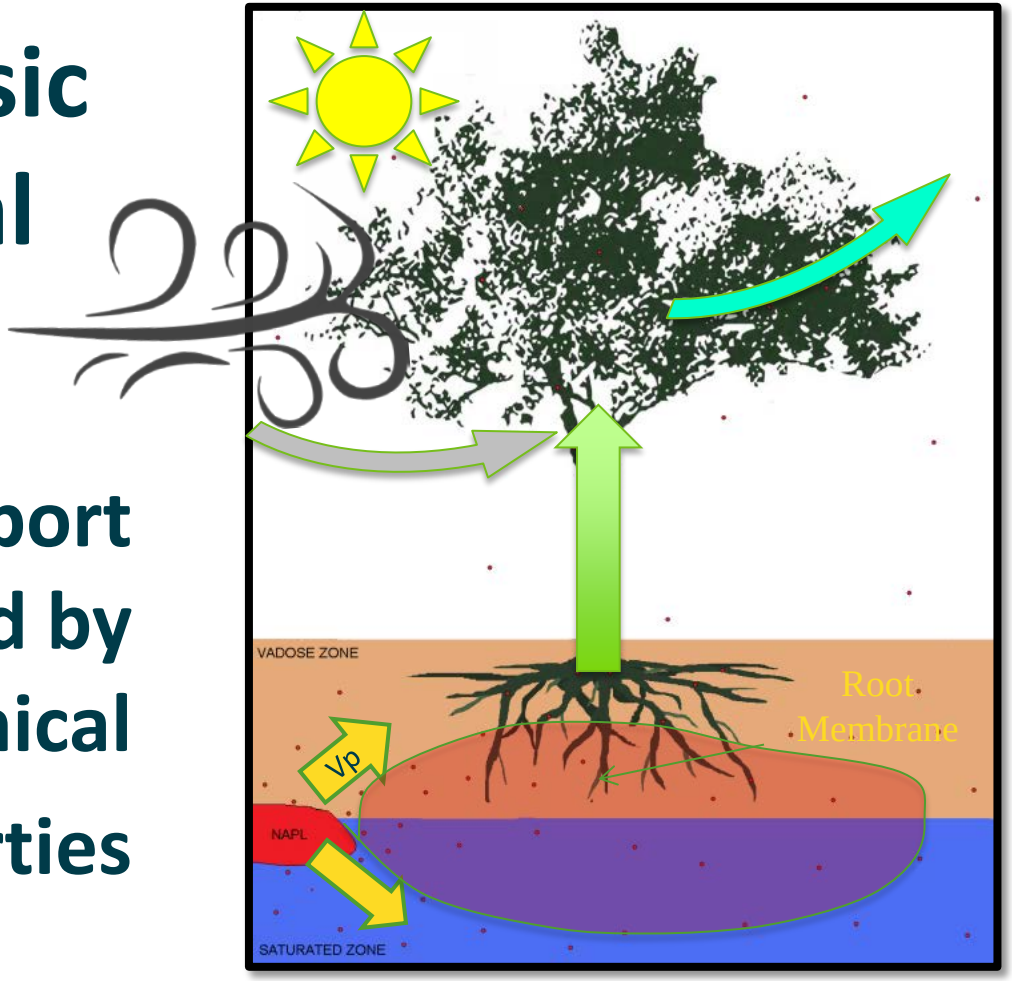
Phytoforensic Conceptual Model



Transport characterized by chemical properties

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Tree Coring

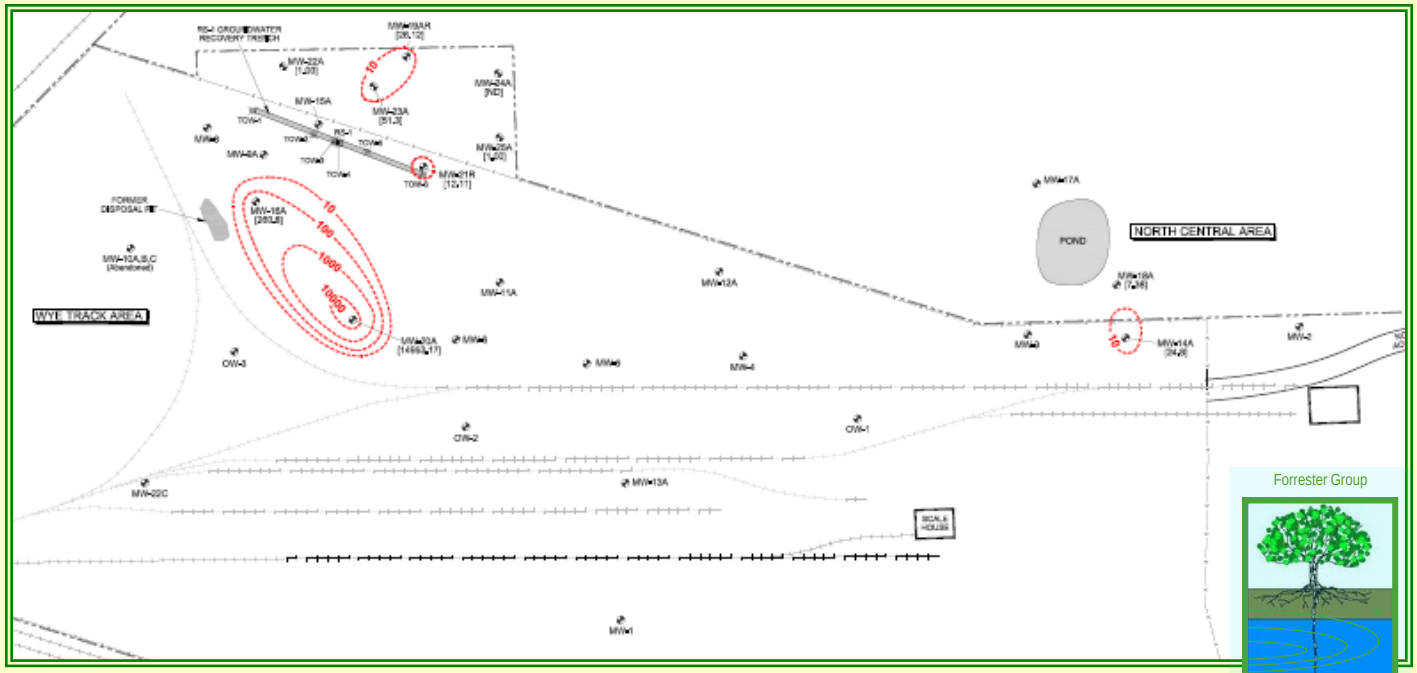
- Methods: D. Vroblesky - USGS
- Collect a core sample of the trunk/stem
- Core sample placed into vial
- After equilibration time headspace GC analysis
- Partition coefficients determine concentrations

Headspace Analysis

Field Site – Sedalia Missouri

PCE and TCE contaminated site in Old railroad yard. Site investigation over 10 years, 40 sampling points.

Source remains elusive

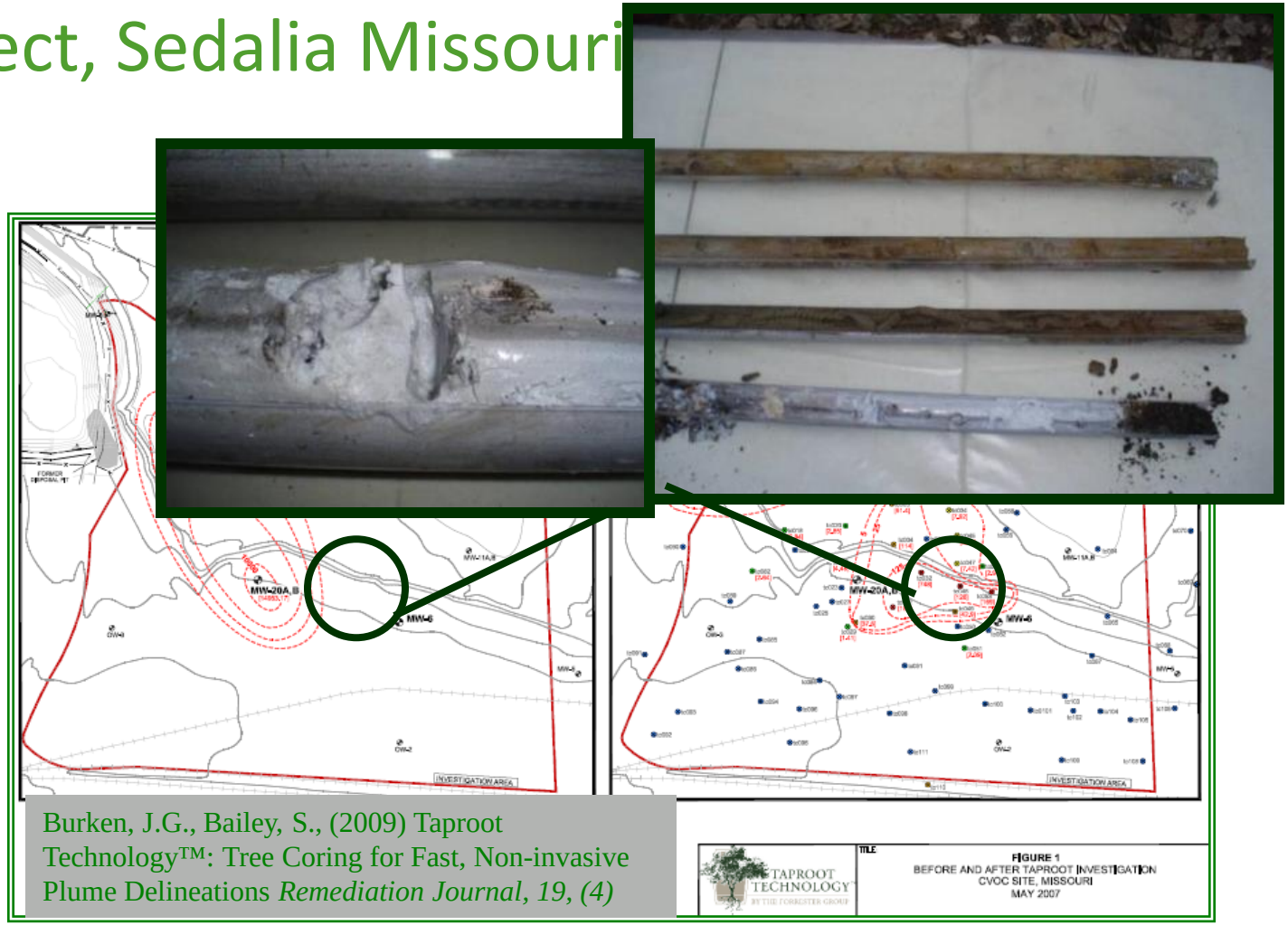


Forrester Group

TapRoot™

RR Site… 12 years of investigation, remedy in place.

Chlorinated Solvents Sampling Project, Sedalia Missouri

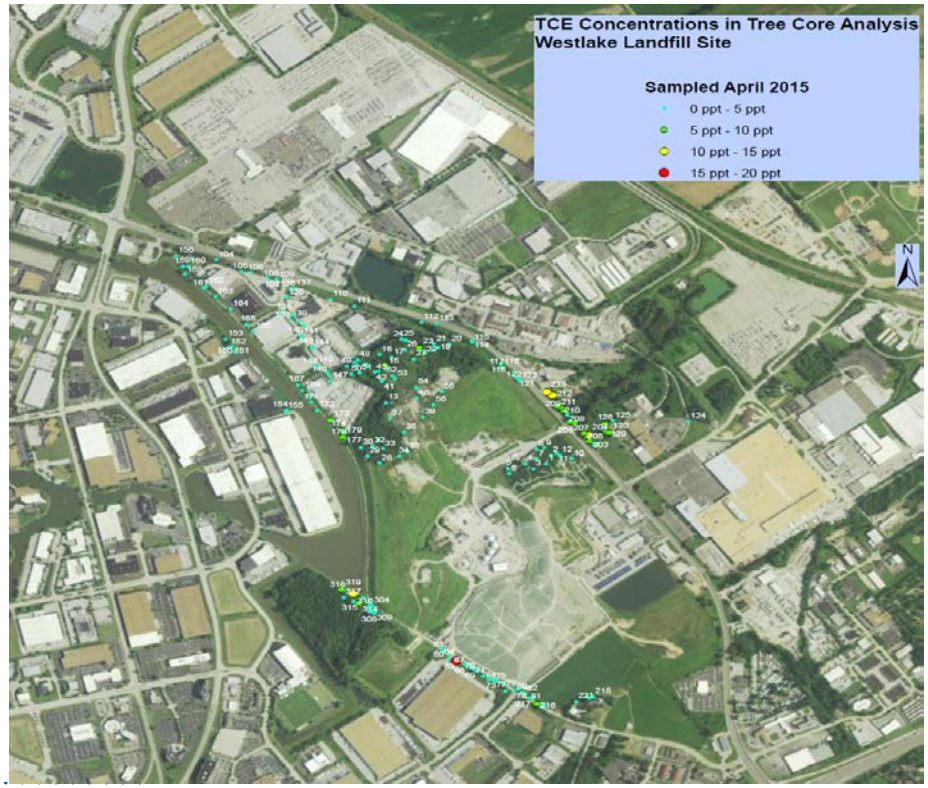


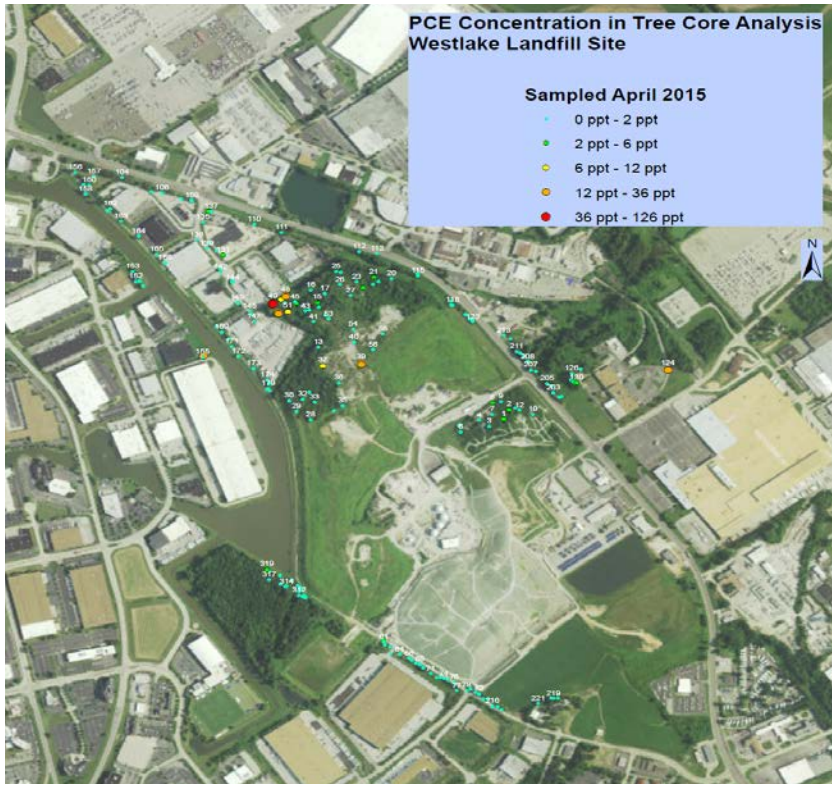
Burken, J.G., Bailey, S., (2009) Taproot Technology™: Tree Coring for Fast, Non-invasive Plume Delineations *Remediation Journal*, *19, (4)*

114 samples = 1 day, 4 person crew

Phytoforensics:Bridgeton Landfill

Phytoforensics:Bridgeton Landfill





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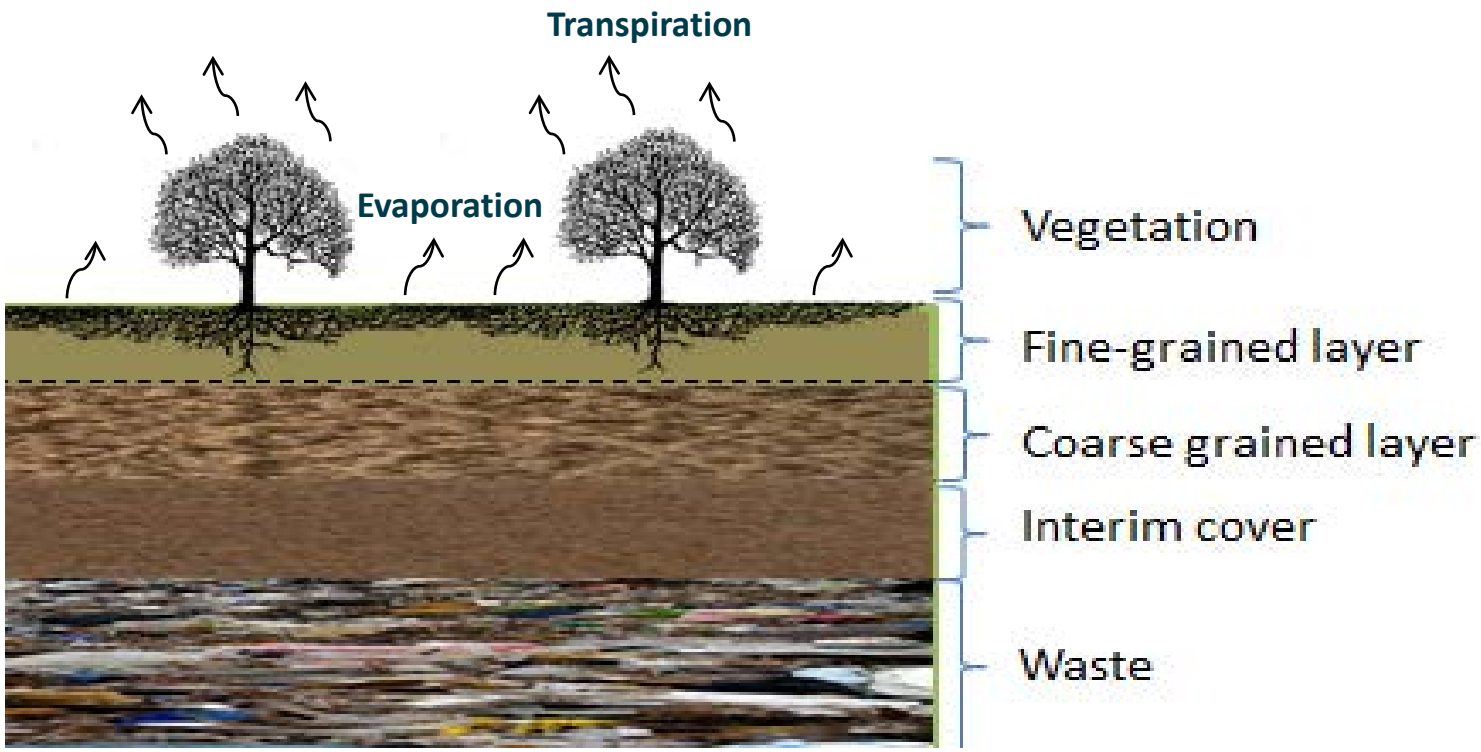
Phytoforensics Landfills

Phytoforensics overall

- >88 sites, 14 landfills
- 8 countries, 16 states
- Broad Acceptance: EPA, USGS, EU, ITRC
- 11 Chlorinated solvents
- BTEX
- Perchlorate
- RDX

ET covers & Leachate treatment

- Water management
  - Storage and Evaporation – soil
  - Transpiration – plants
- Soil properties
  - Porosity, water holding capacity, soil texture, and organic matter content.
- Plants are actively involved
  - Erosion control and soil stabilization
  - Natural system
- Self-repairing
- More economical than most conventional covers

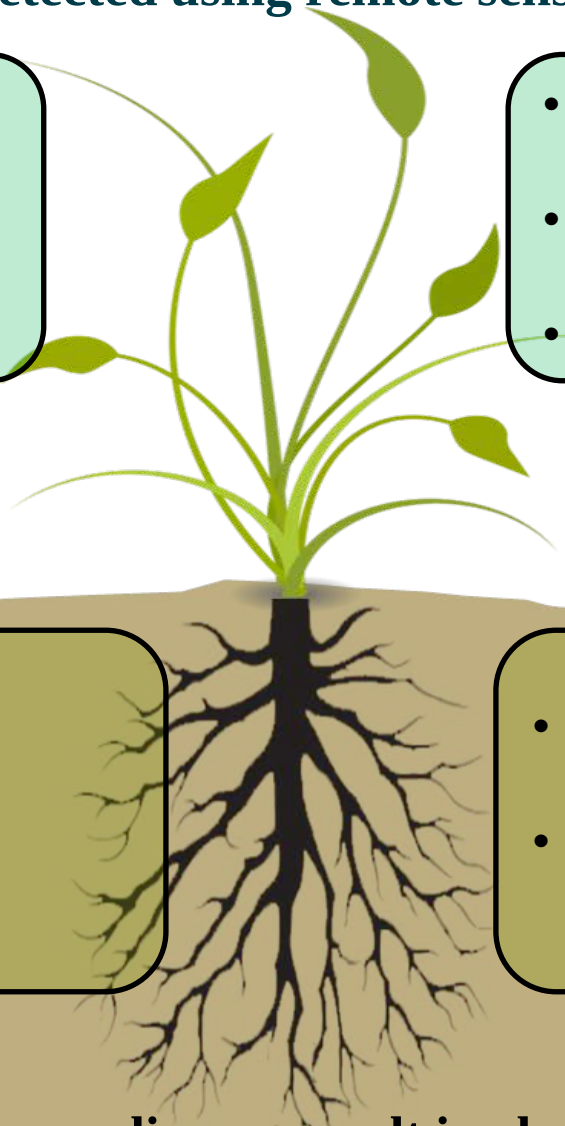


Plant functions - landfill scenario

Changes can be detected using remote sensing technologies

- **Water balance**
- **Evapotranspiration Covers**
- **Run-off control**

- **Deposition of particulate matter**
- **Canopy obstructing raindrops**
- **CO_2 utilization**



- **Degradation**
- **Erosion control**
- **Soil Stabilization**
- **Soil Conservation**

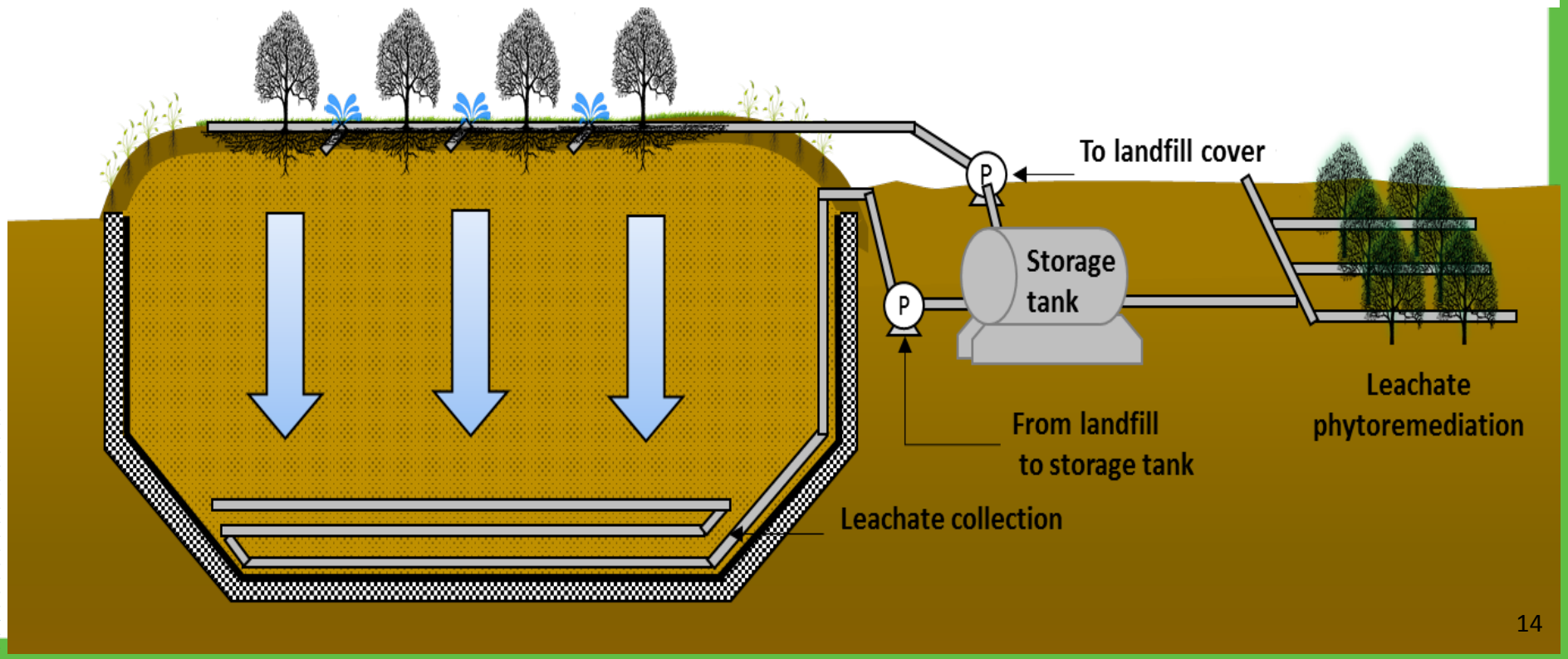
- **Uptake of organic and inorganic compounds**
- **Phytoforensic assessment of subsurface contaminants**

Changes in the media can result in changes in plants

Leachate recirculation or treatment

- Plant health and survival – key to effective treatment
- Management practices for vegetation
  - Not yet established - Can be monitored using remote sensing technologies
- Enhances solid waste stabilization
- ET Modeling can project site and plant specific water management

  250,000 to 400,000 gallon/acre/year for Midwest sites (Ecolotree & Leachate



Today in Missouri – Owensville

www.leachate.us

LEACHATE
MANAGEMENT SPECIALISTS

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Active projects for leachate

- Collaboration with
  - Ecolotree
  - Leachate Management Systems
  - US Forest Service
  - Missouri S&T

Figure 3. Average annual water balance for considered scenarios

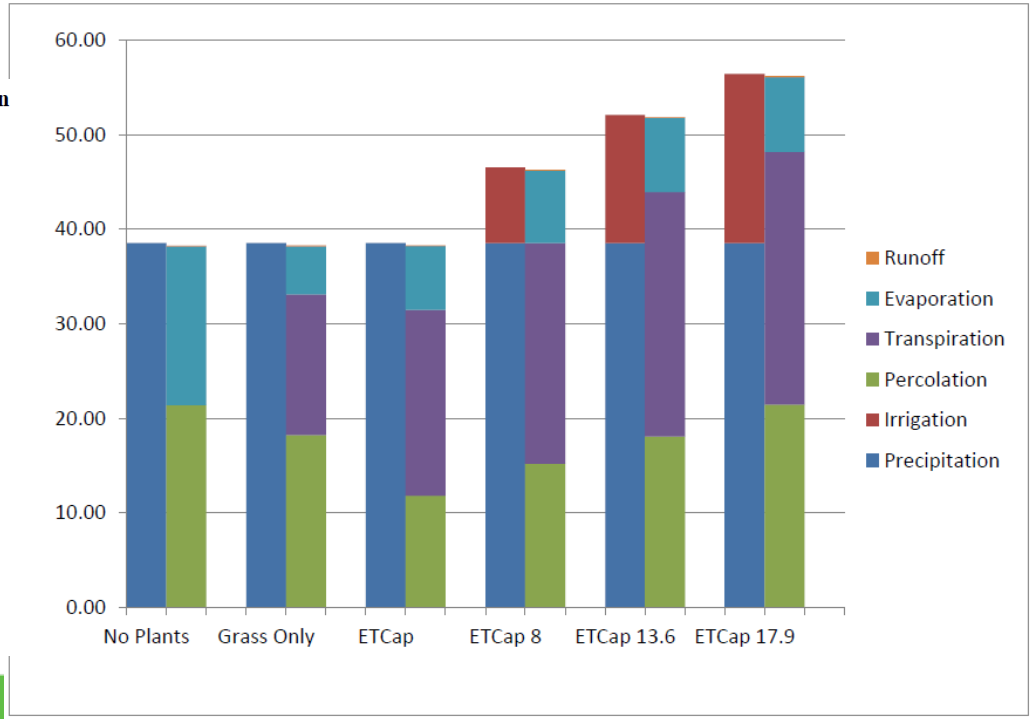
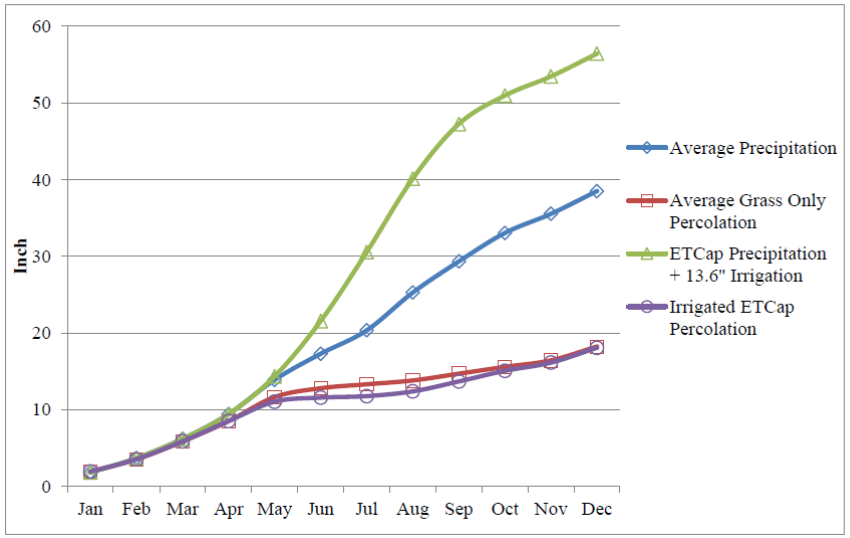
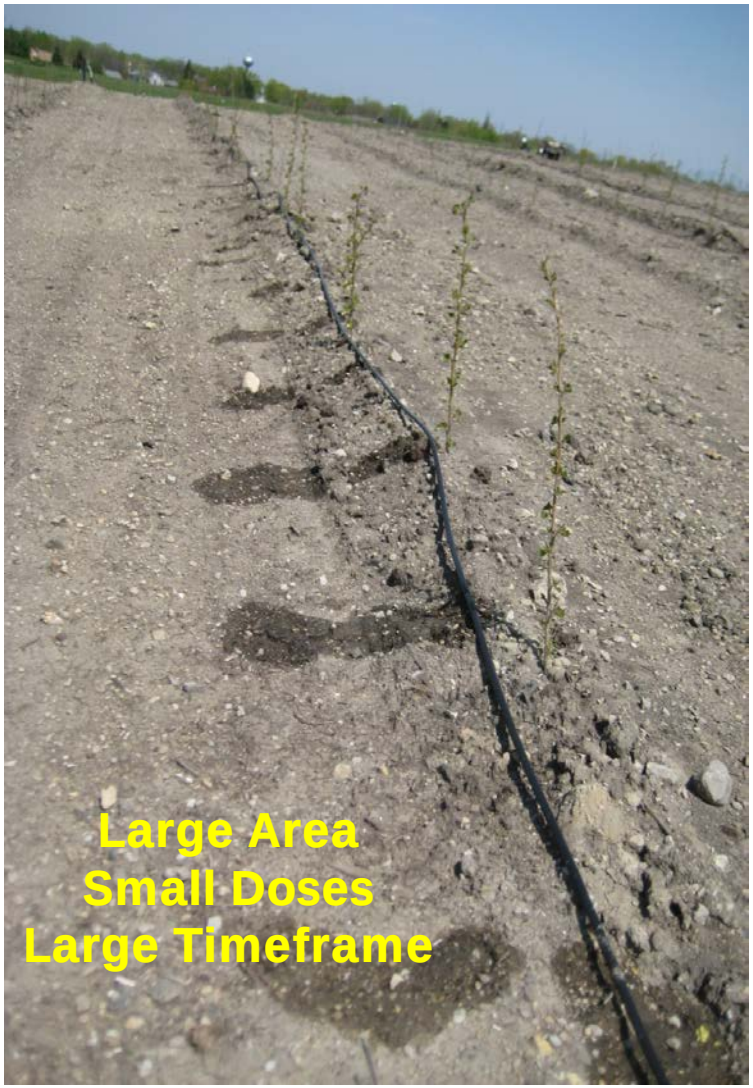


Figure 4. Average cumulated water balance for grass only and ETCap 13.6-inch irrigation



Drip irrigation



LEACHATE
MANAGEMENT SPECIALISTS

Poplar Trees – Jeffco – First Growing Season

TREE GROWTH

April 2008

Jeffco – 5 Months Post Planting September 2008

ecolotree

LEACHATE MANAGEMENT SPECIALISTS

Jeffco Results

Summer 2010 – Jeffco

	Leachate Utilization*										
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Totals
Leachate Volume (millions)	2.9	4.3	4.25	4.95	3.8	2	3.4	4	4.4	4.2	38.2

Fall 2011 – Jeffco

Not a single load of leachate has left the site since system startup

T&D avoided = $0.058 x 38,200,000 = >$2.2 million

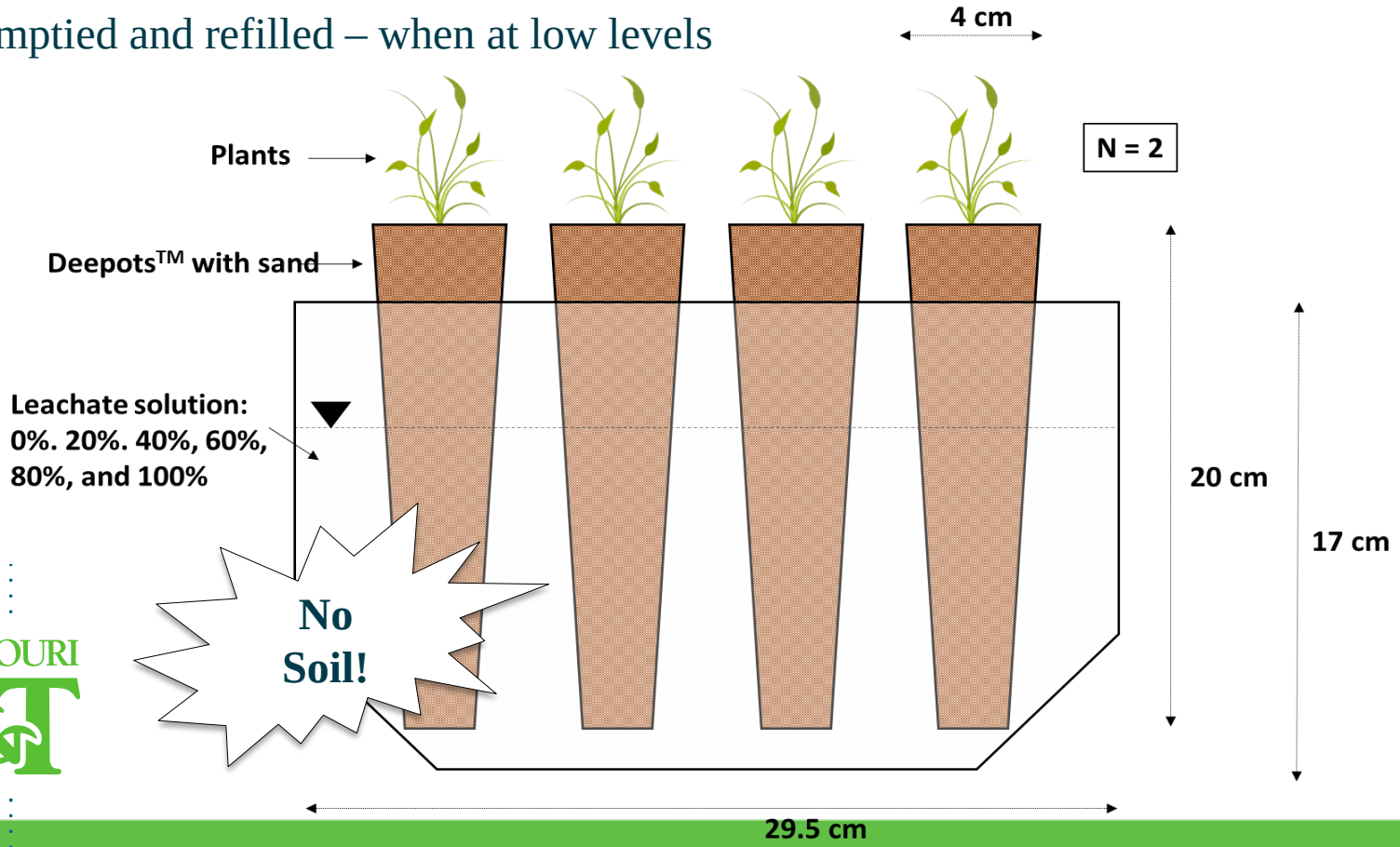
ecolotree

LEACHATE MANAGEMENT SPECIALISTS

Laboratory - Bioassay of plants @ S&T

- Leachate
  - 20%, 40%, 60%, 80% and 100%
  - 0% - DI water
  - Hoagland's nutrient solution
- 75 days greenhouse study
- Emptied and refilled – when at low levels

- Biomass and leaf counts
- Root **architecture**
- Hyperspectral **reflectance**



Remote sensing - Hyperspectral

Headwall Nano-Hyperspec® hyperspectral VNIR Imager (Headwall Ph

- Range: **400n**
- Mountable o
- Captures **ima**
- Used for:
  - Food safet
  - Forestry
  - Precision agriculture

FieldSpec®-Pro (Analytical Spectral Devices (ASD) Inc.)

n to 2500nm

ctance

terization

alysis

- Pigment analysis

Same concept but different technology

Pearson's correlation coefficient $r = 0.997$

Coefficient of determination $r^2 = 0.994$

Calculated probability p-value <0.001

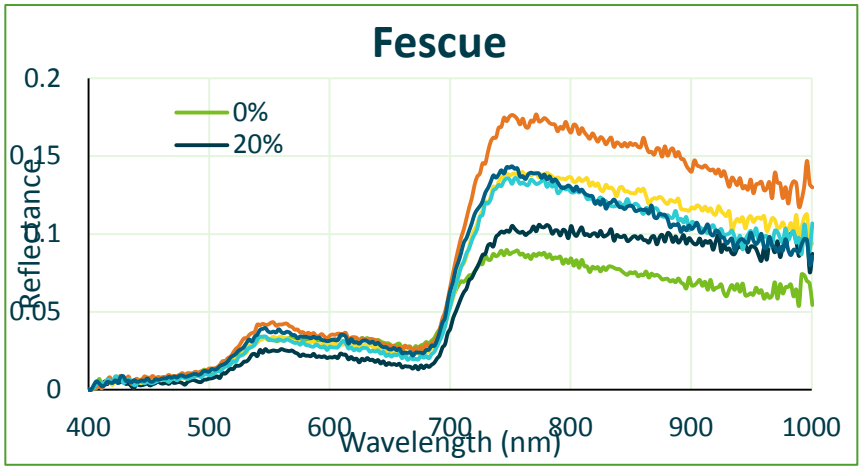


Image: http://www.headwallphotonics.com

Image: http://hyperspektral.geo.uni-halle.de

Results

1. Plant Bioassay

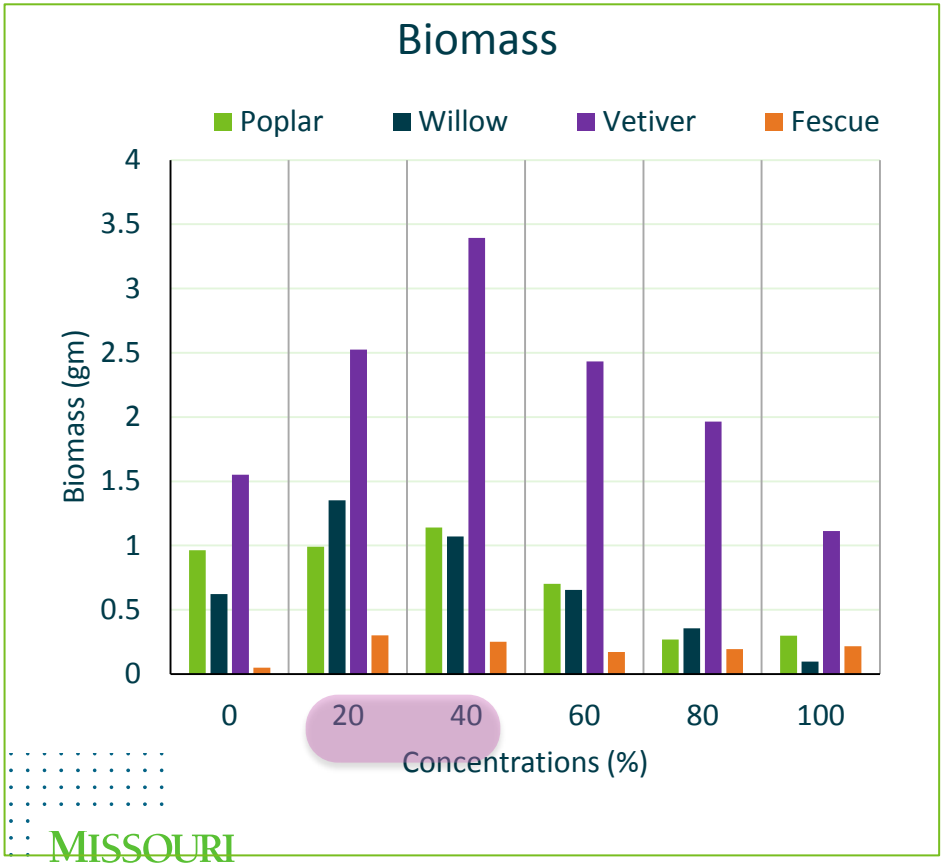


Figure 2 (a). Biomass vs Concentration (%)

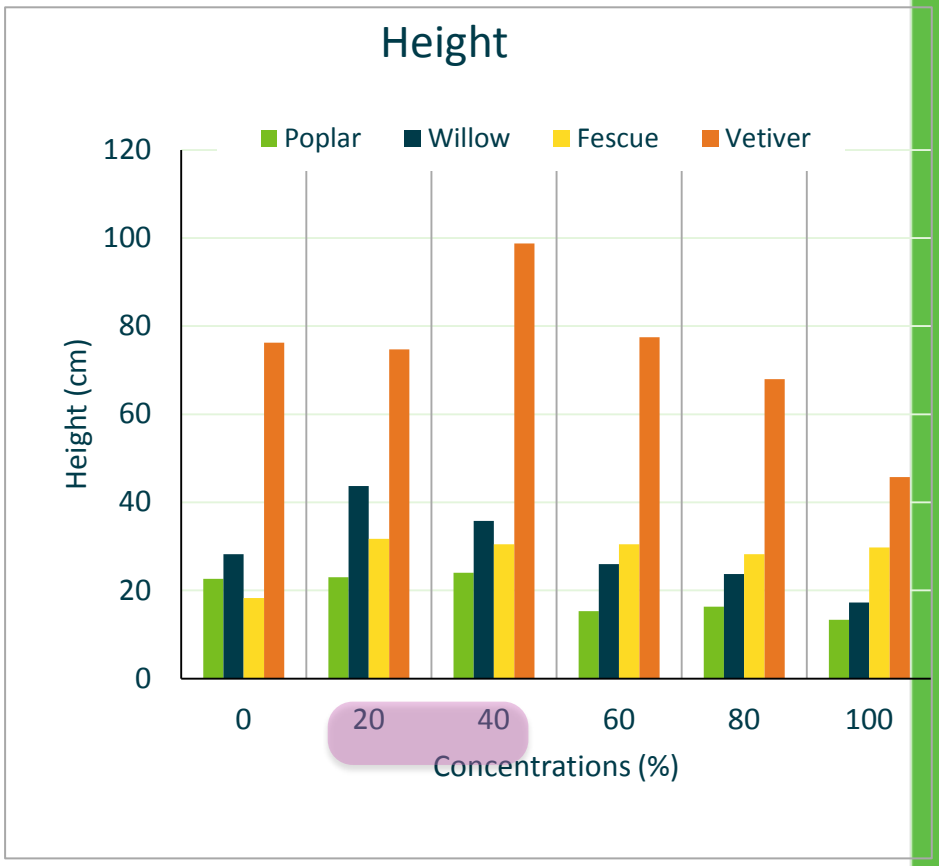


Figure 2 (b). Height vs Concentration (%)

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Results

1. Plant Bioassay

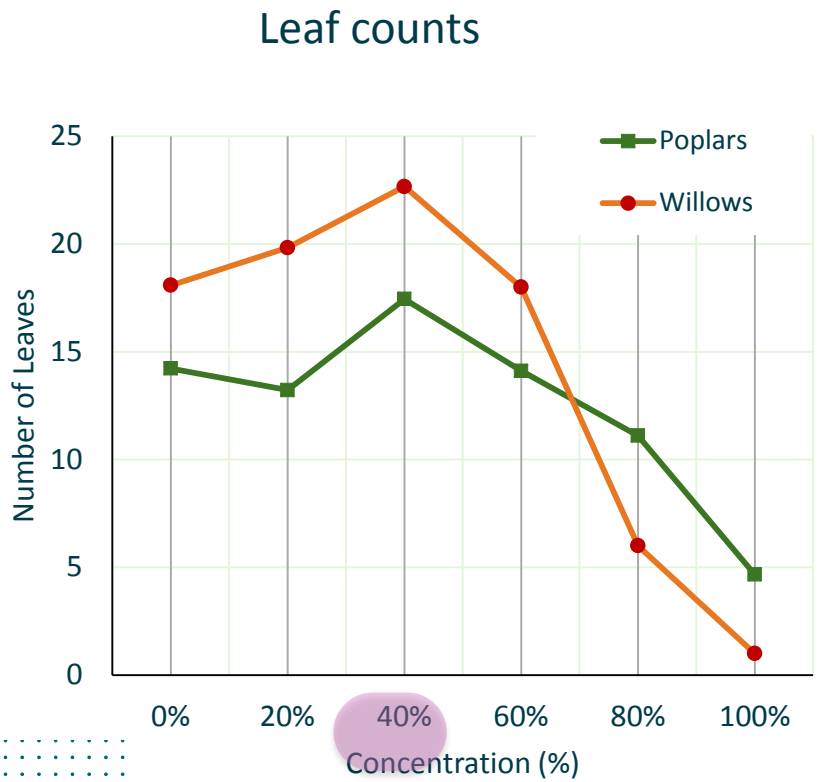


Figure 3 (a). Number of leaves vs Concentration (%).

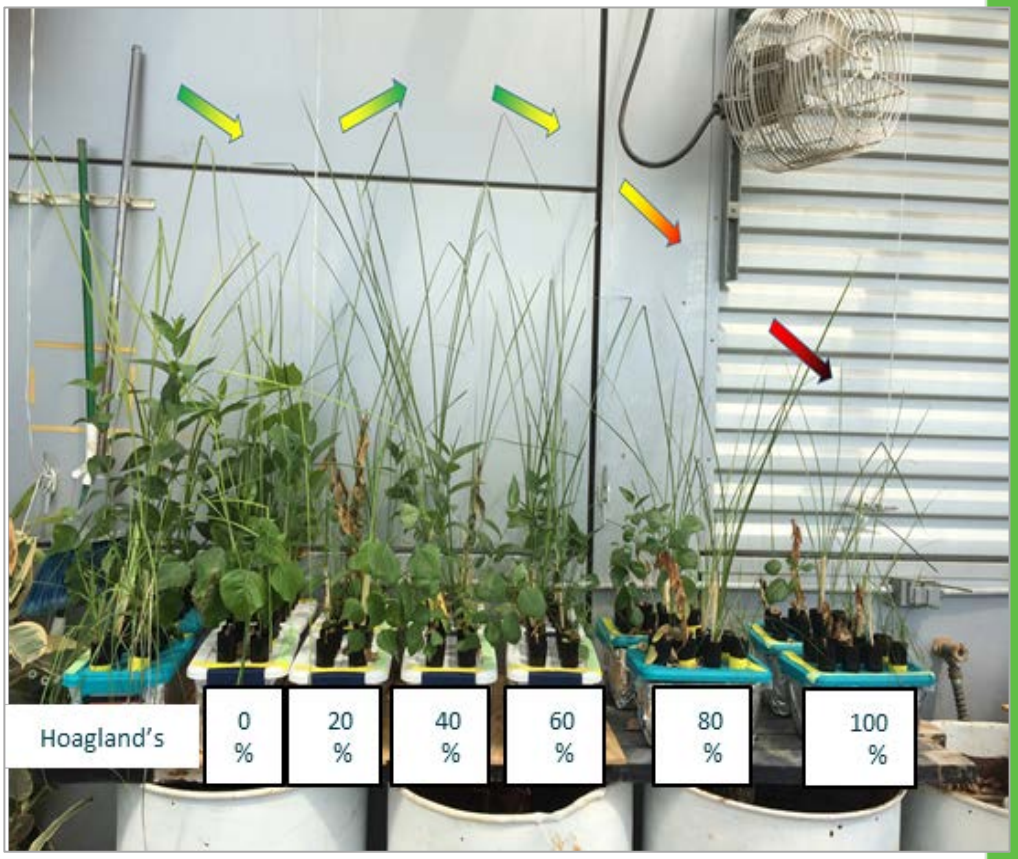
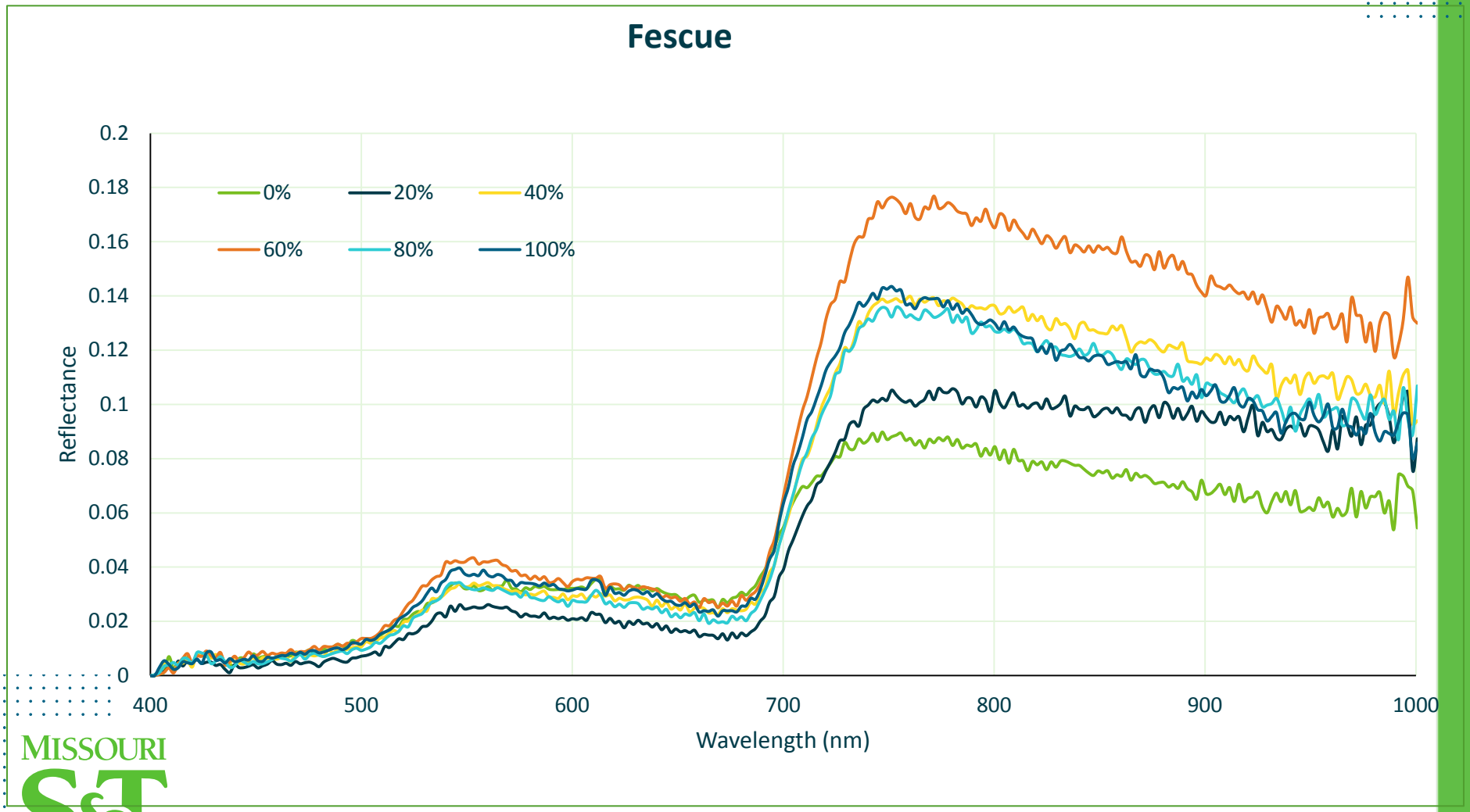


Figure 3 (b). Bioassay experiment, increasing leachate concentration from left to right

Methods



Spectral data for bioassay study, showing the raw hyperspectral data

Results

Normalized Difference Vegetation Index

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

- **NDVI705:**
  - Red Edge Normalized Difference Vegetation Index
  - Canopy foliage content and senescence
  - Vegetation Range: 0.2 to 0.9

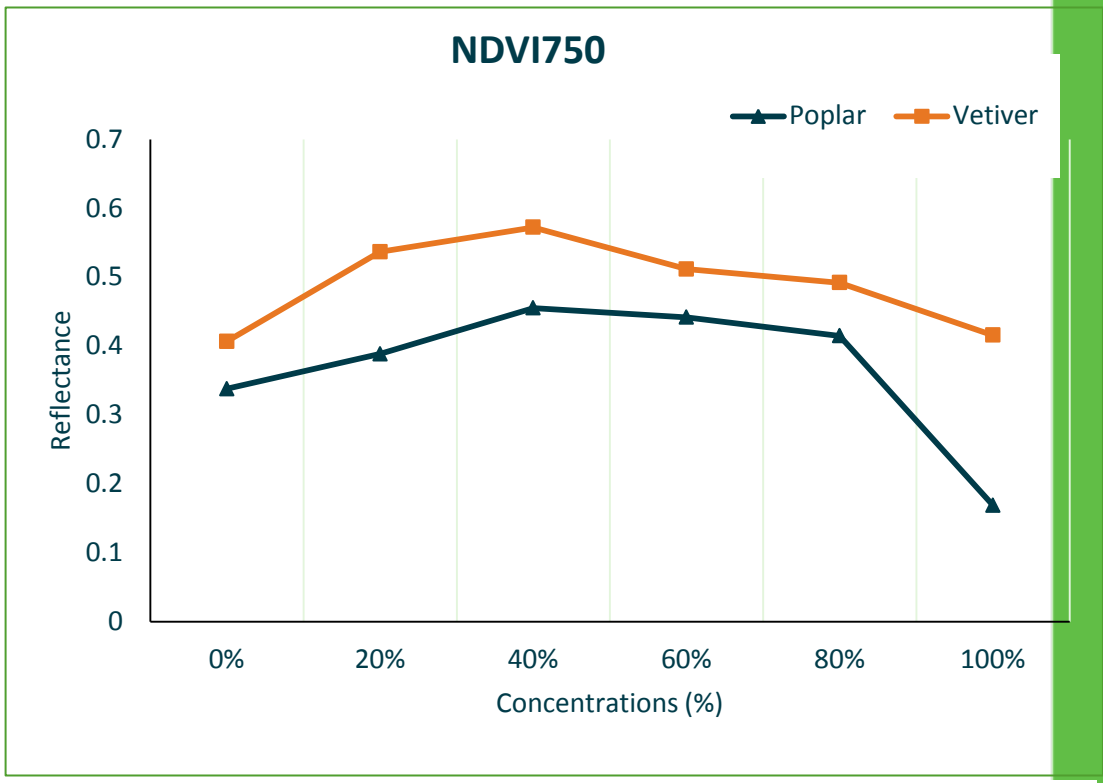


Figure 8. Plot showing NDVI750 at different concentrations (%)

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Methods

4. Radiometric measurements:

- Range of 350 to 2500nm.
- Handheld operation

FieldSpec Pro spectro-radiometer

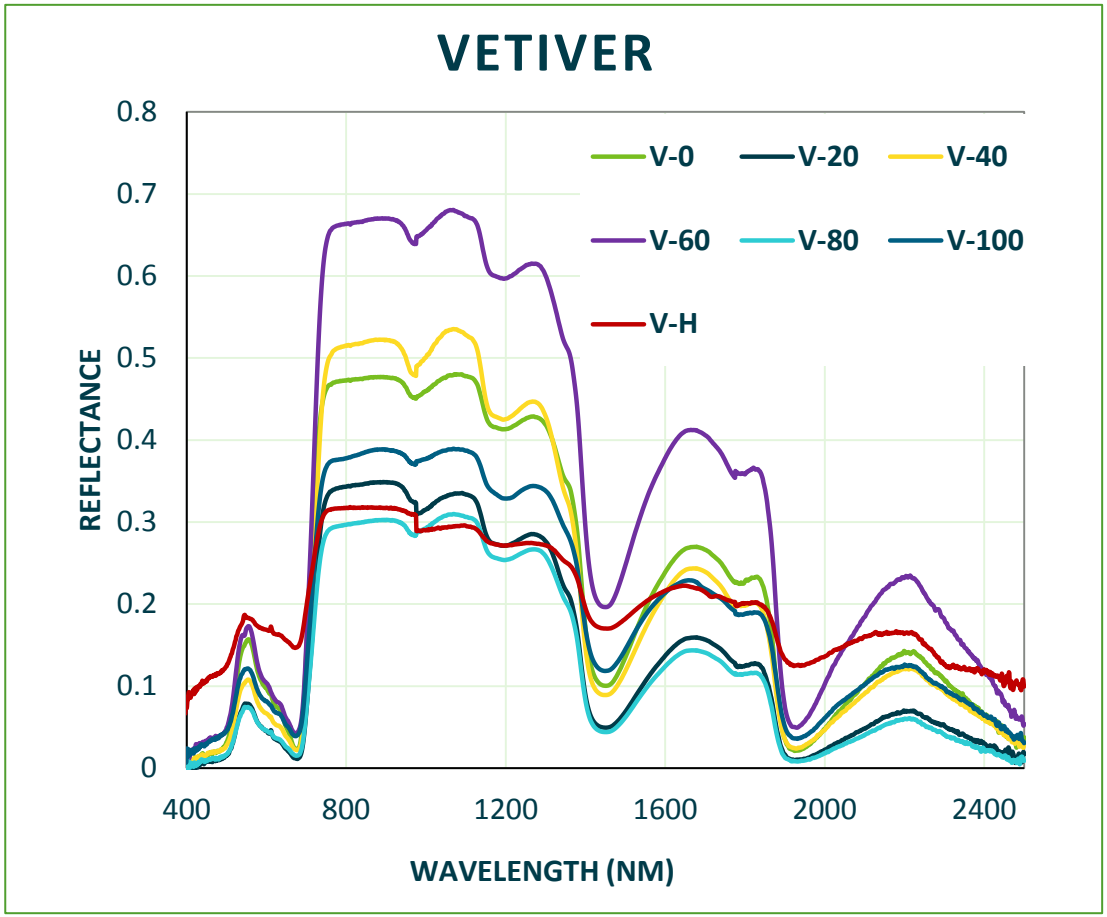
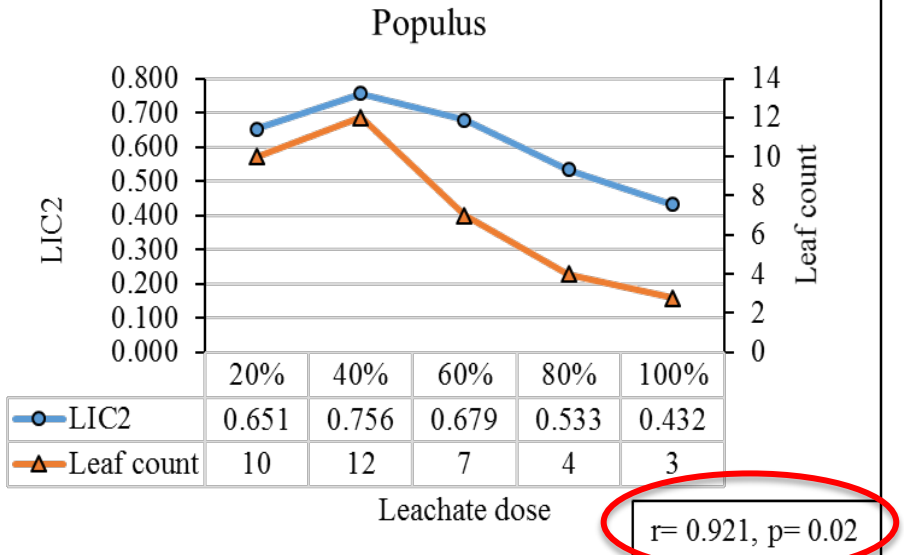
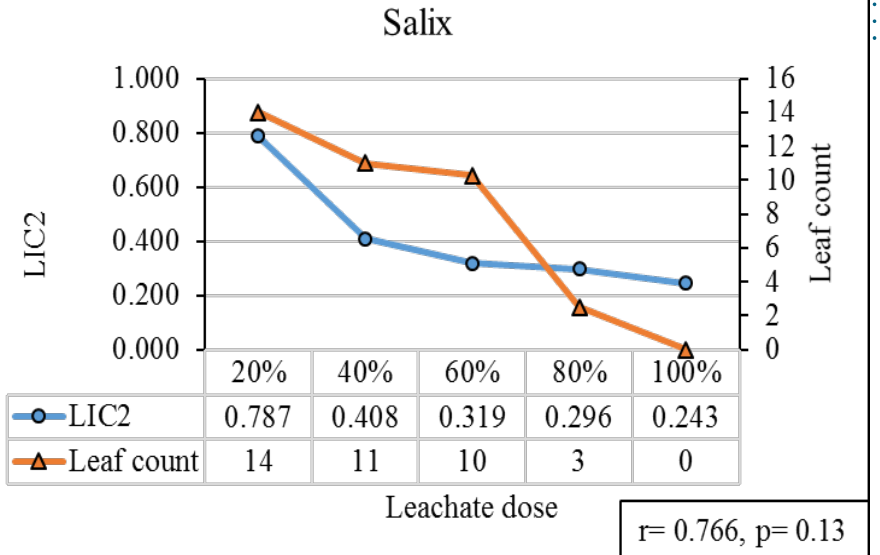


Figure 7. Spectral data for bioassay study, showing the raw radiometric data

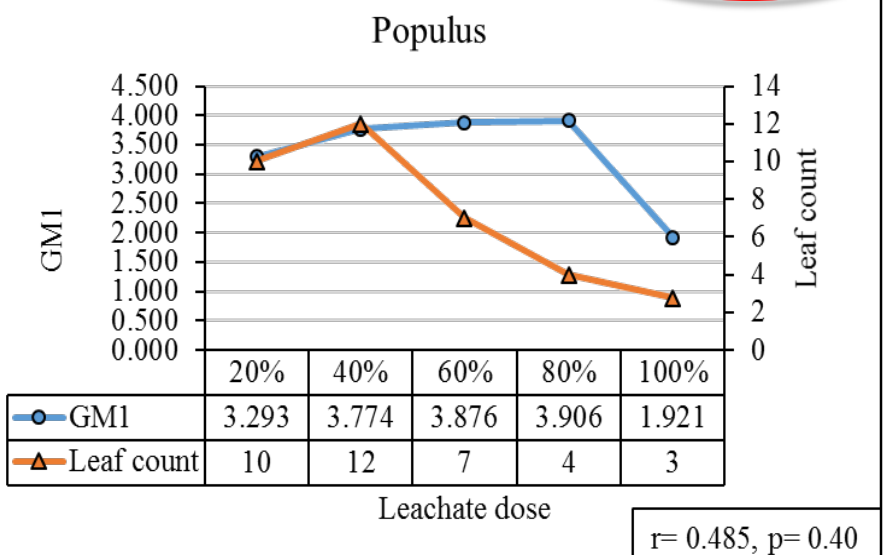
FieldSpec®-Pro – Dicots (leaf count)



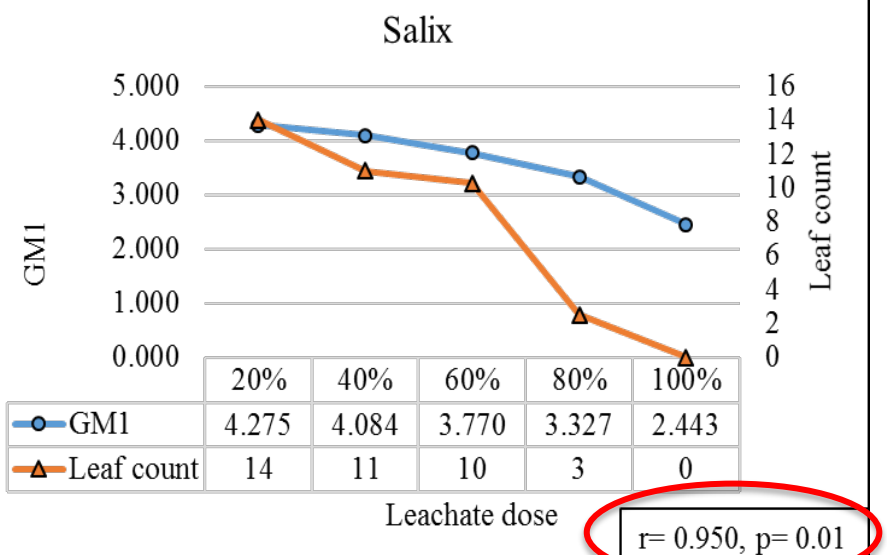
r= 0.921, p= 0.02



r= 0.766, p= 0.13

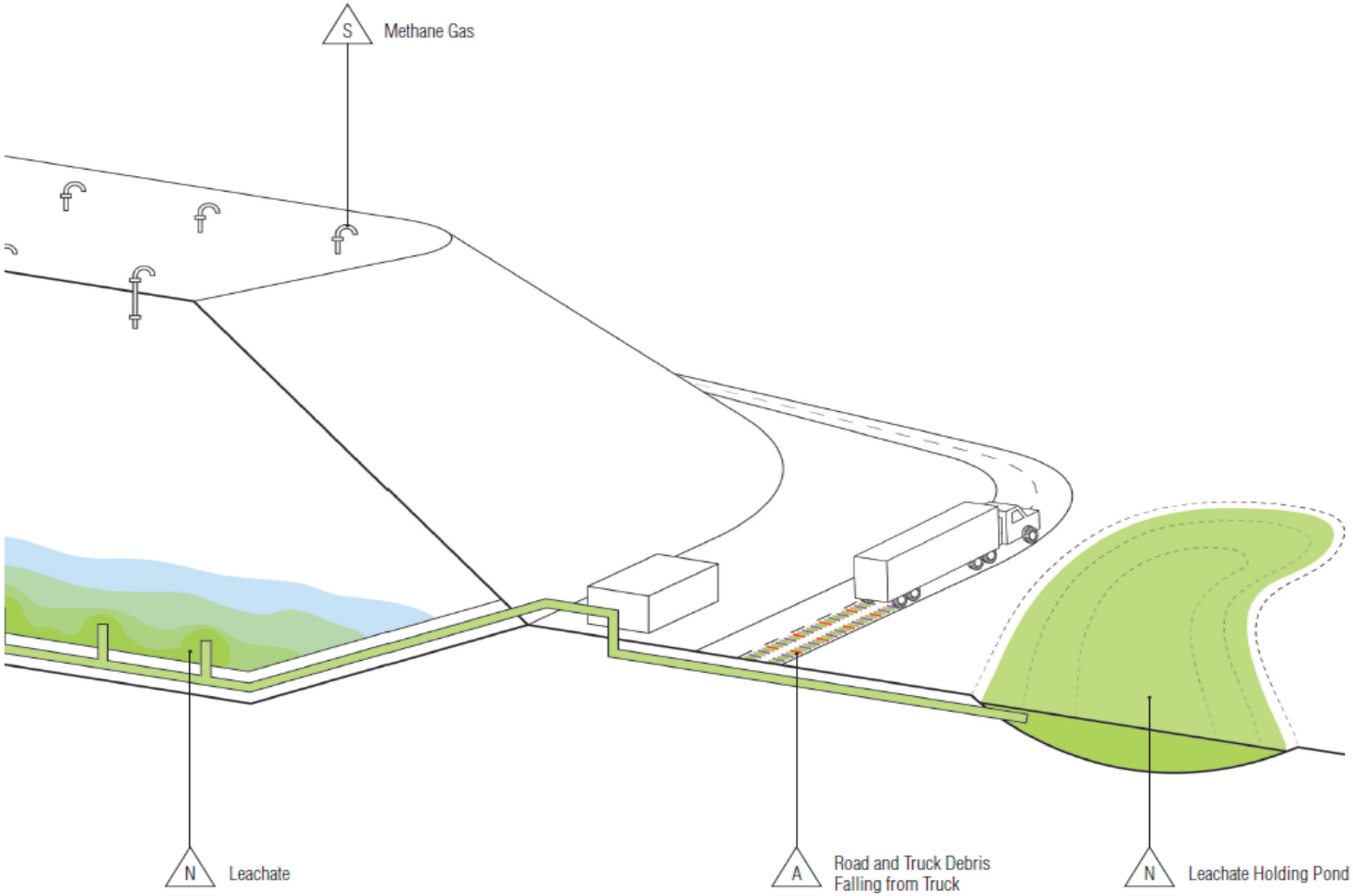


r= 0.485, p= 0.40



r= 0.950, p= 0.01

Benefits…

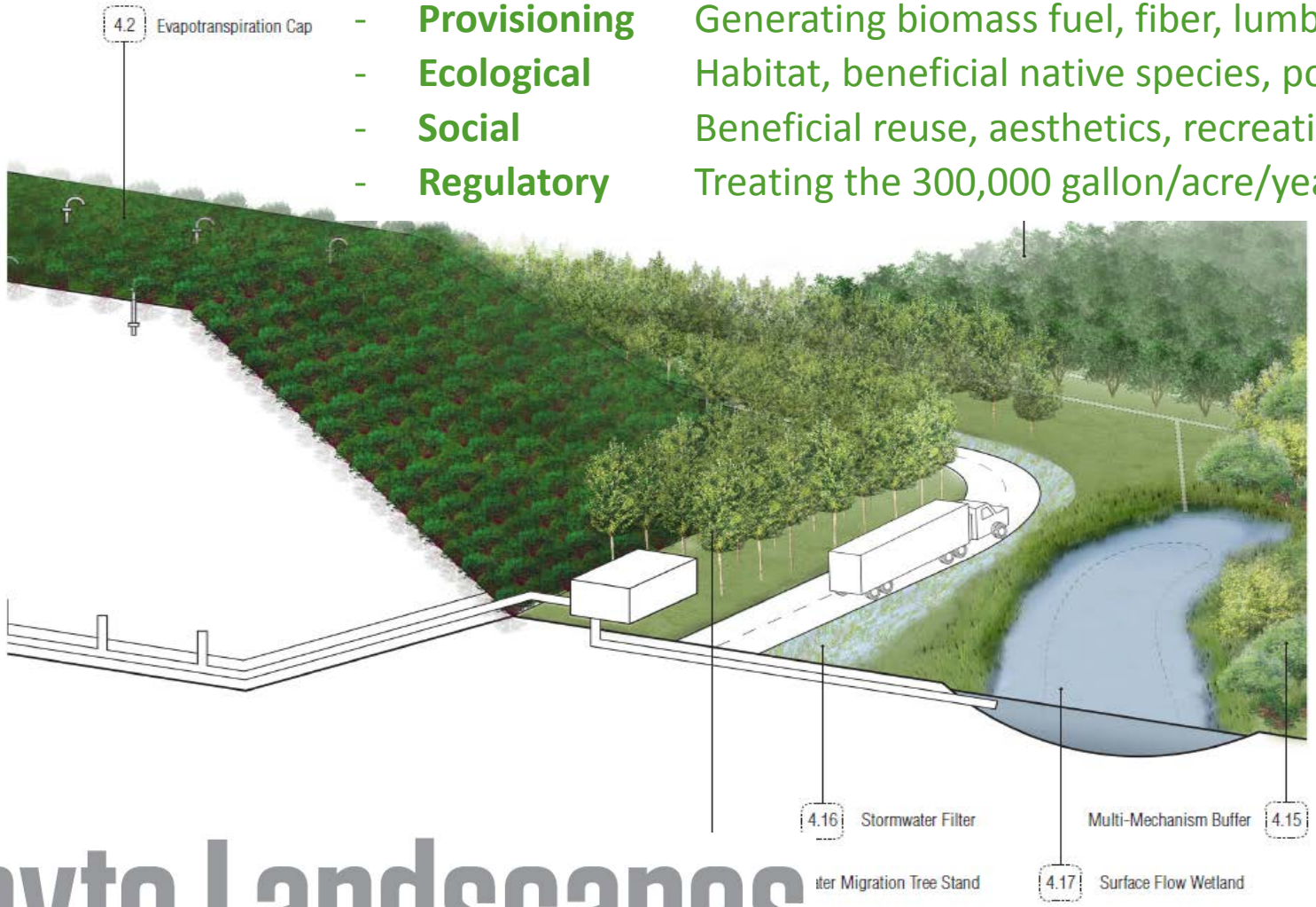


Landfill

Benefits…

Ecosystem services

- **Provisioning** Generating biomass fuel, fiber, lumber
- **Ecological** Habitat, beneficial native species, pollinator
- **Social** Beneficial reuse, aesthetics, recreation
- **Regulatory** Treating the 300,000 gallon/acre/year



Thank you!

Joel Burken, Missouri S&T

> burken@mst.edu

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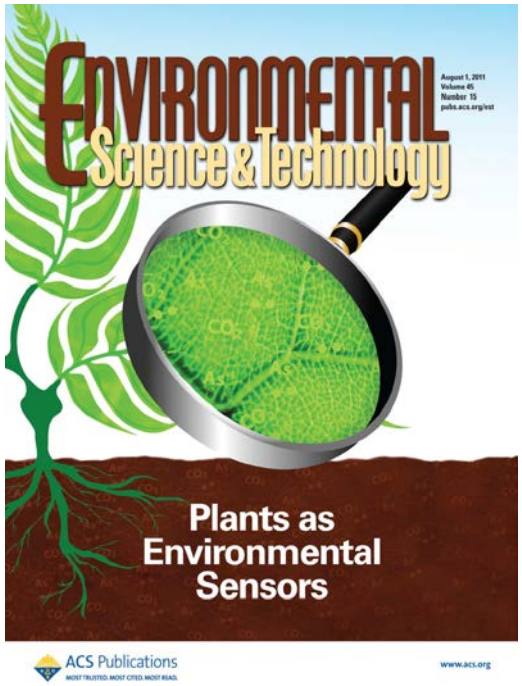

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