



***Third International Phytotechnologies Conference
April 20-22, 2005 Atlanta***

Phytoremediation Are we there yet?

Mike Reynolds

**US Army-Engineer Research and Development Center
Cold Regions Research and Engineering Laboratory
(CRREL)**





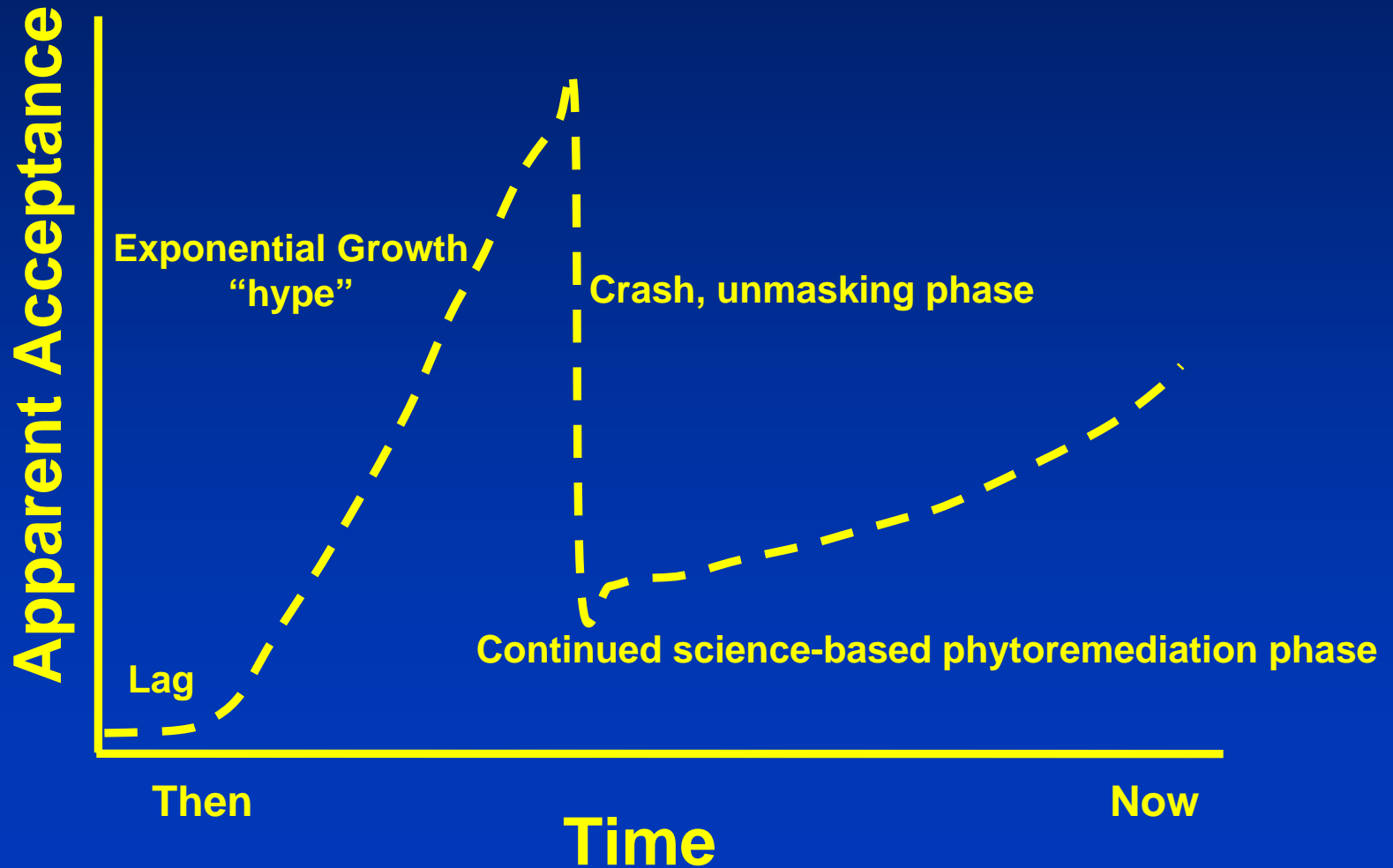
User Questions

- Isn't this just natural attenuation?
- Which plants do we use?
- Are there better plants to use?
- Depth?
- How do we fertilize the plants?
- Cost?
 - Money
 - Time
- How do we know that it is working?
- What if an animal grazes on the plant?
- How long does it take?



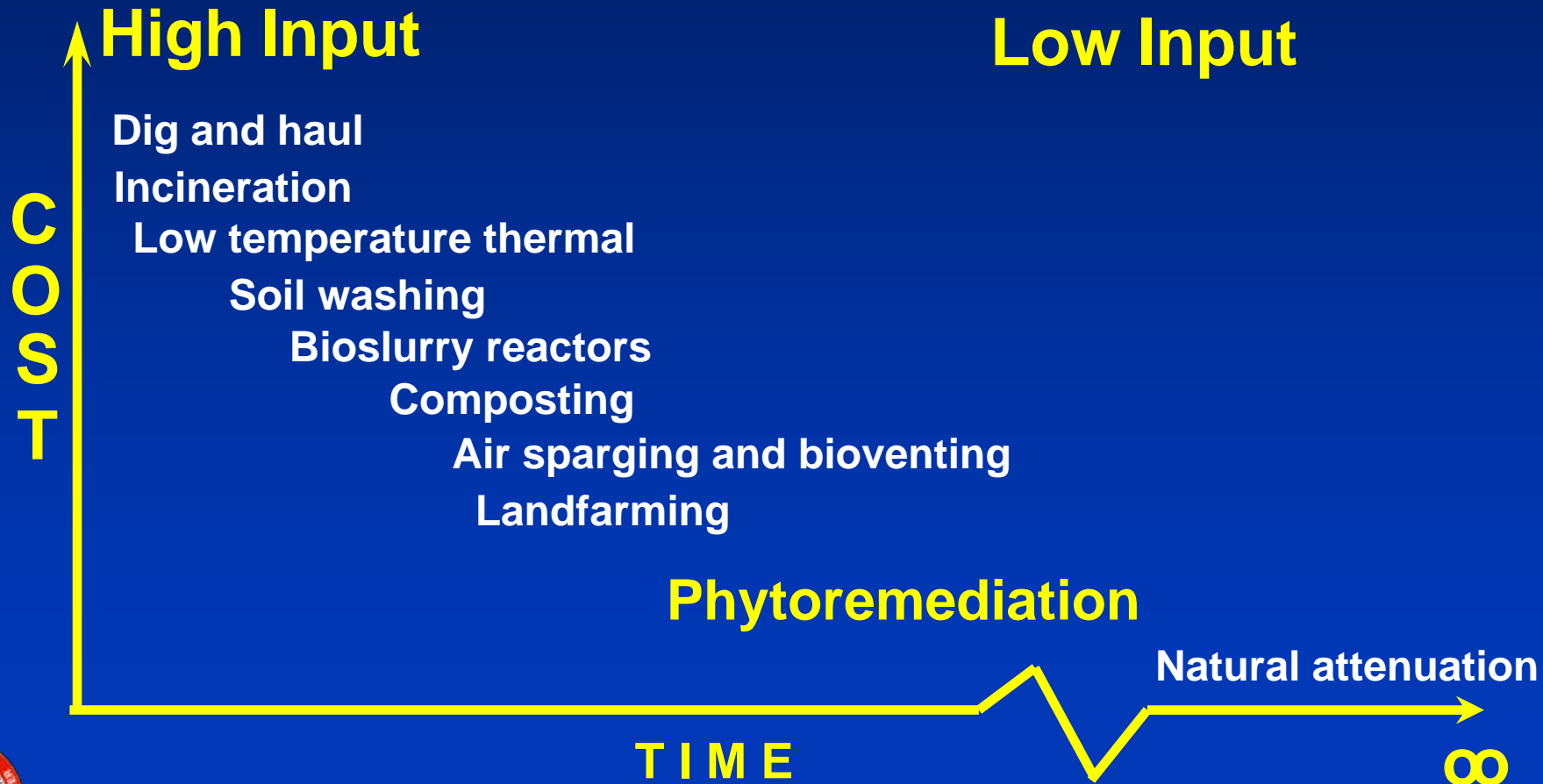


One View of the History of Phytoremediation



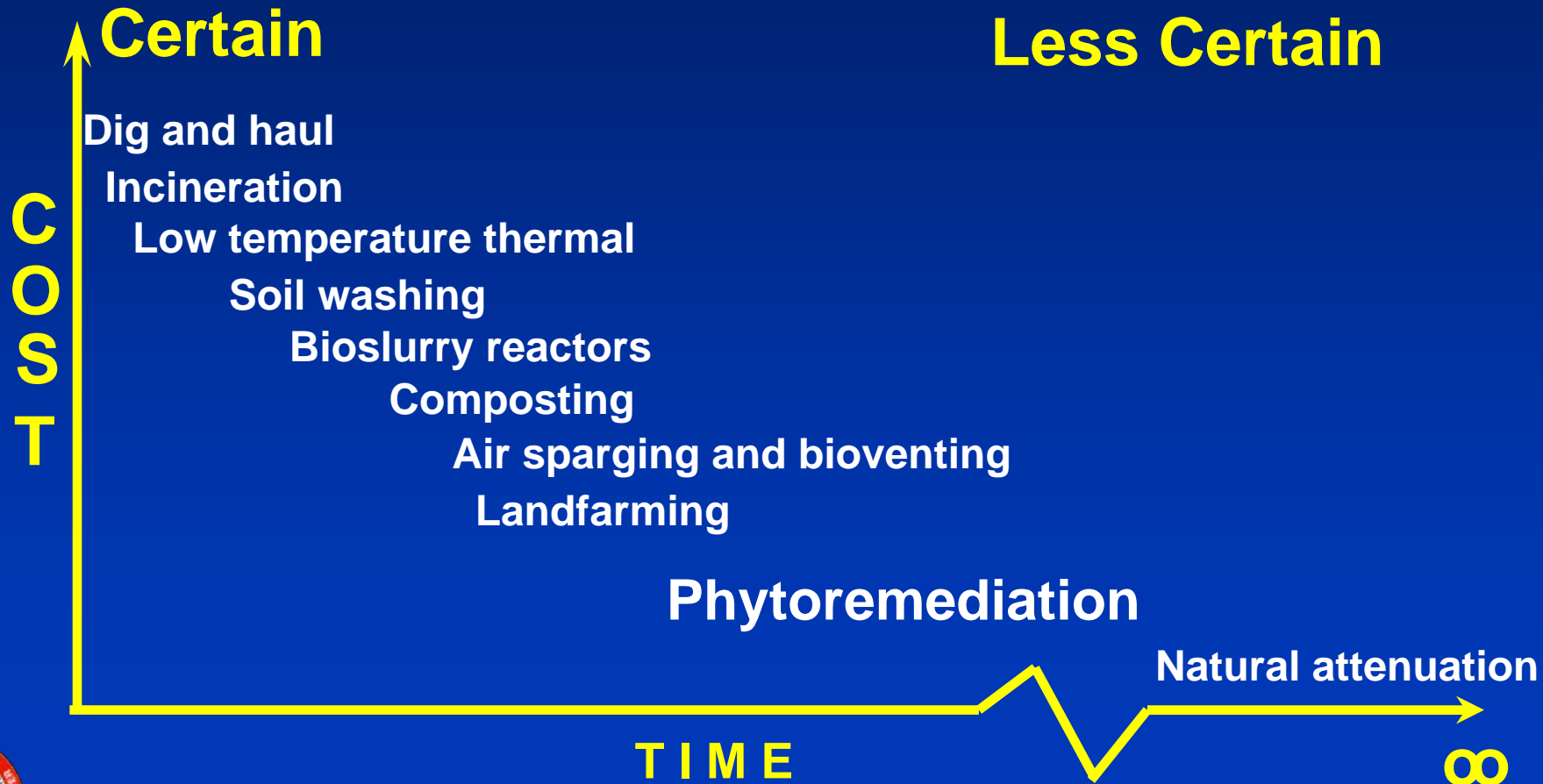


Potential Cost Benefits are Tempered by Treatment Time



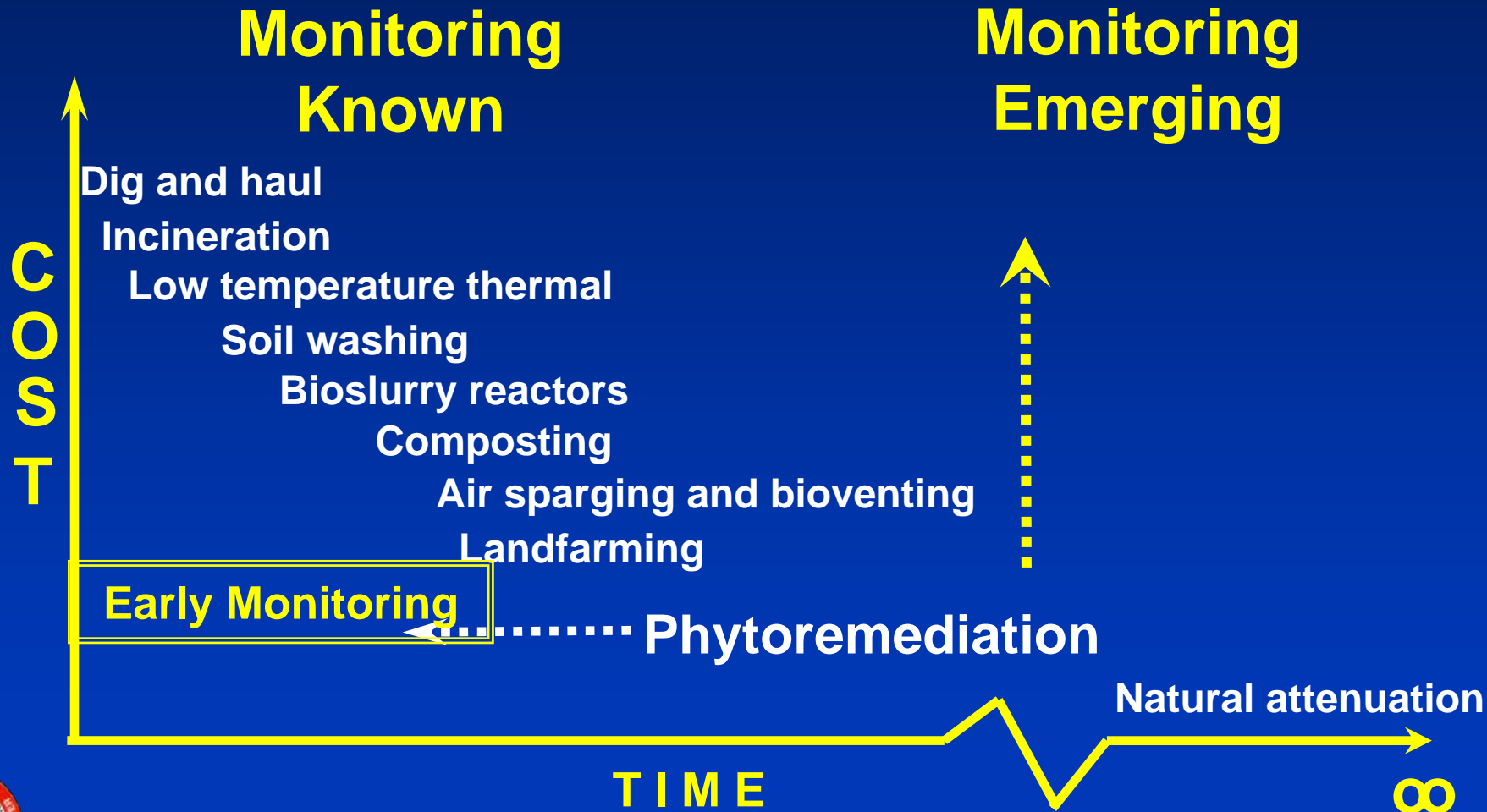


Much of the Cost is Related to the Uncertainty





Relative Inputs and Monitoring Strategies for Remediation





***Are we there yet?...Does this work?
It depends on who you ask...and where
“there” is***

**Joint Interagency Phytoremediation Research
Program PI and PM Meeting, January 2004**

- Consensus of 3 breakout groups included
“monitoring” as a priority**

If you are a researcher, you wonder

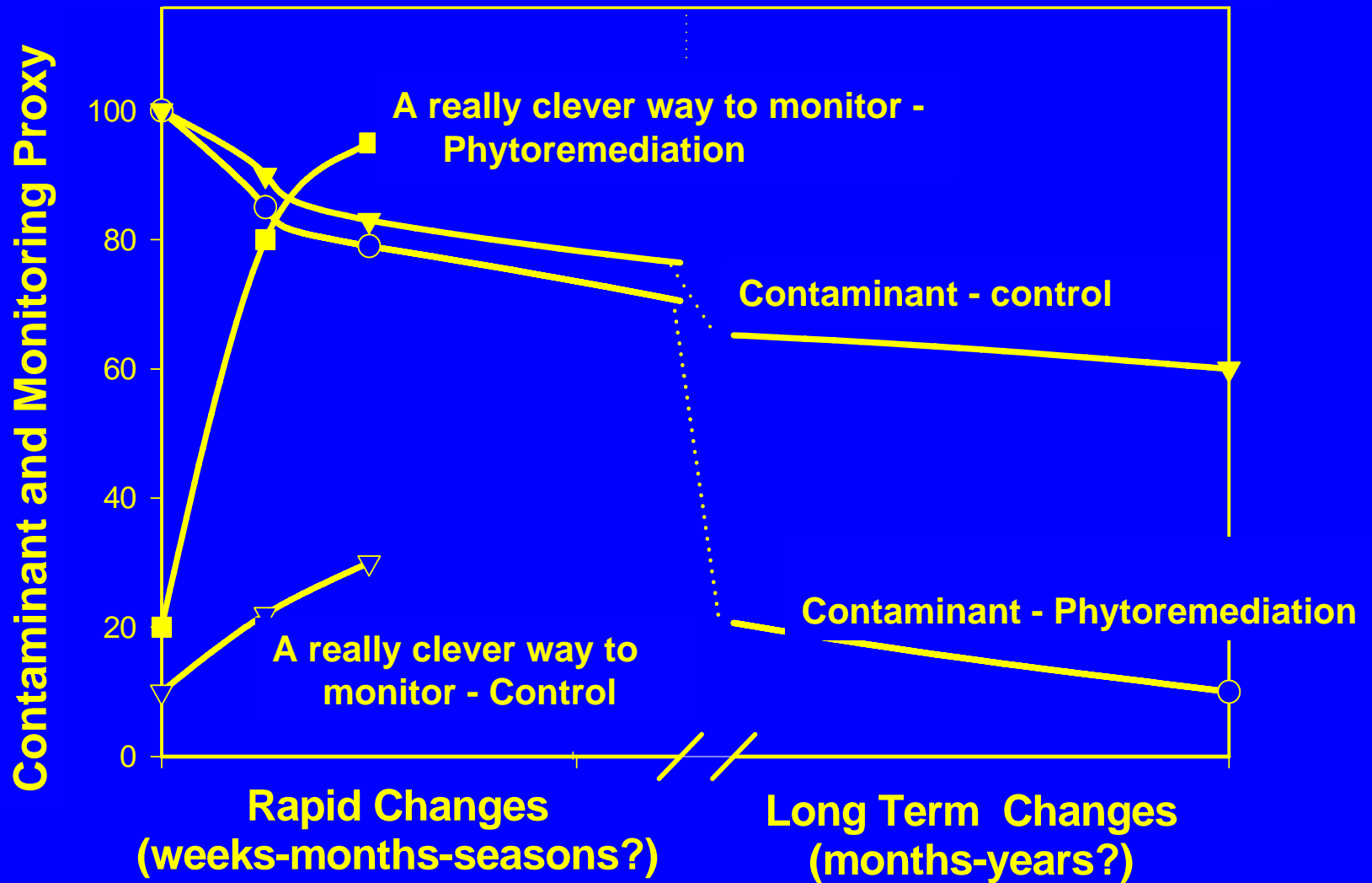
- why your results from field tests did not show
statistical significance**
- or why they did**

**If you work with users or potential users, the
question that always surfaces is:**

“How do I monitor?”



What might early monitoring do for us? Hypothesized Trends in Contaminant and Monitoring Variable



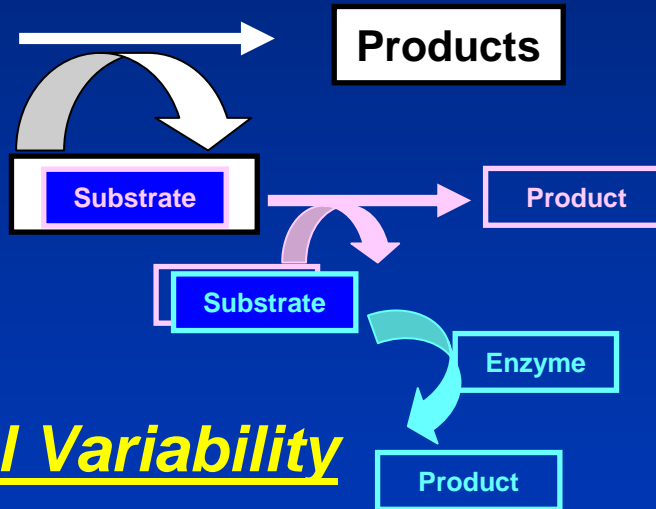


What might work?

Substrate → Product

Spatial variability at many scales ∴ difficult to measure changes

Substrate → Product



We usually measure

- Substrate loss or
- Product formation
- Measure “Microorganisms” or Enzyme activity?

• But they are ephemeral in soil...?

There is now also Temporal Variability

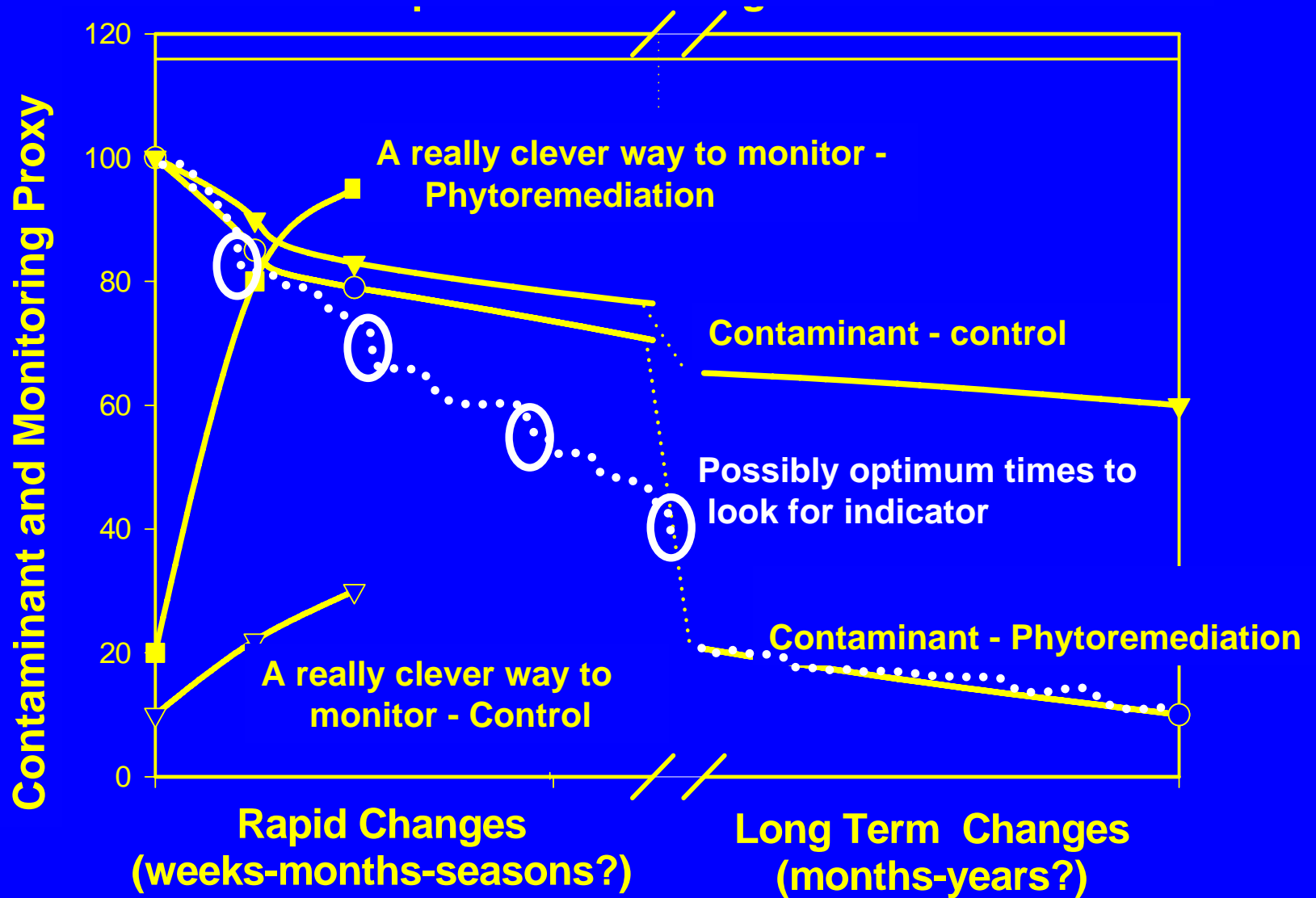
Measure enzyme *production*,

- Measure the *expression* of the genes that code for enzymes
- AND measure when the expression is likely to be happening

Molecular techniques
Coupled with field “realities”

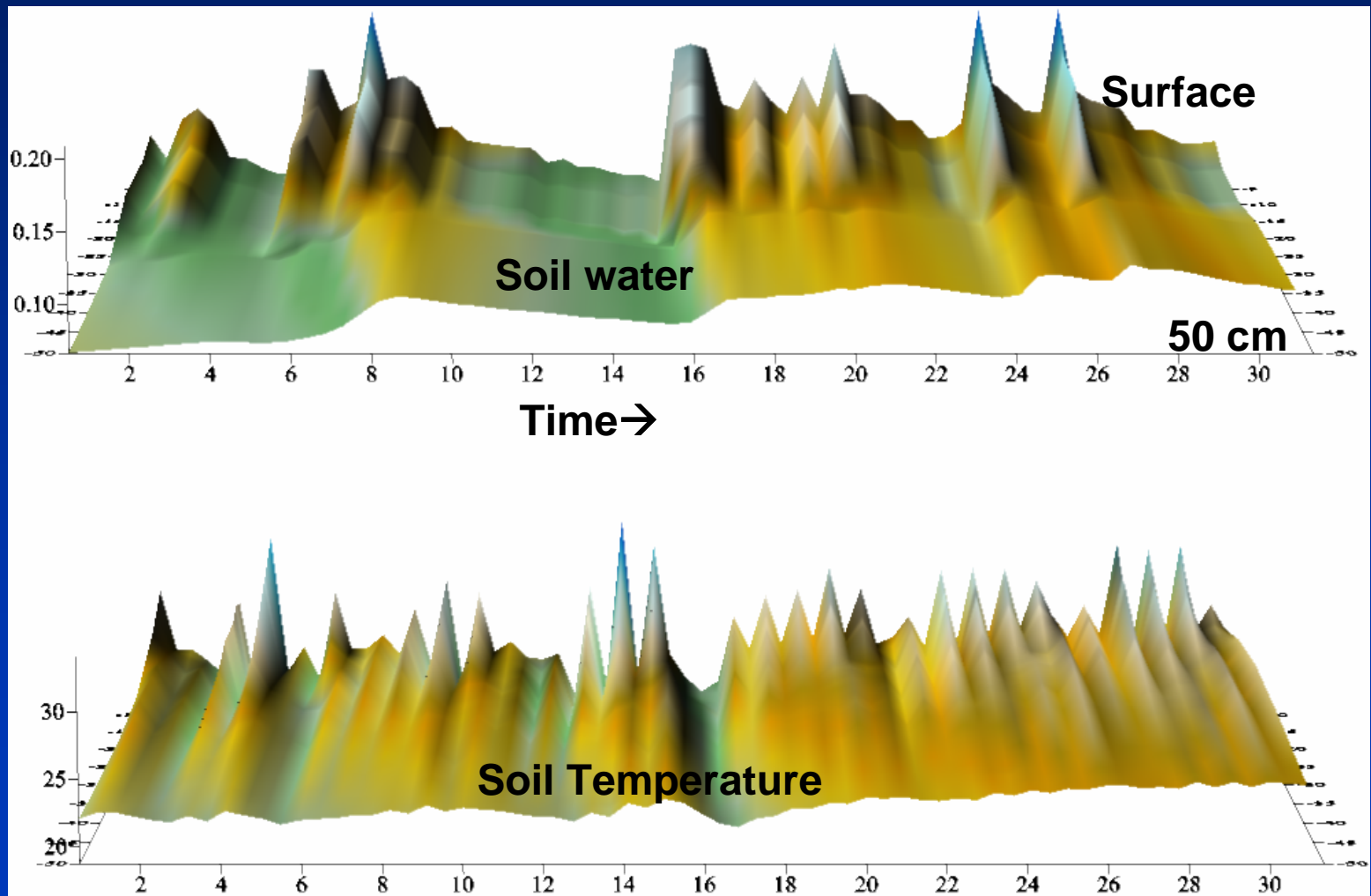


What might field realities be? Hypothesized Trends in Contaminant and Monitoring Variable



Dynamic Nature of Surface Soil

One month of soil water and soil temperature dynamic in CRREL's backyard





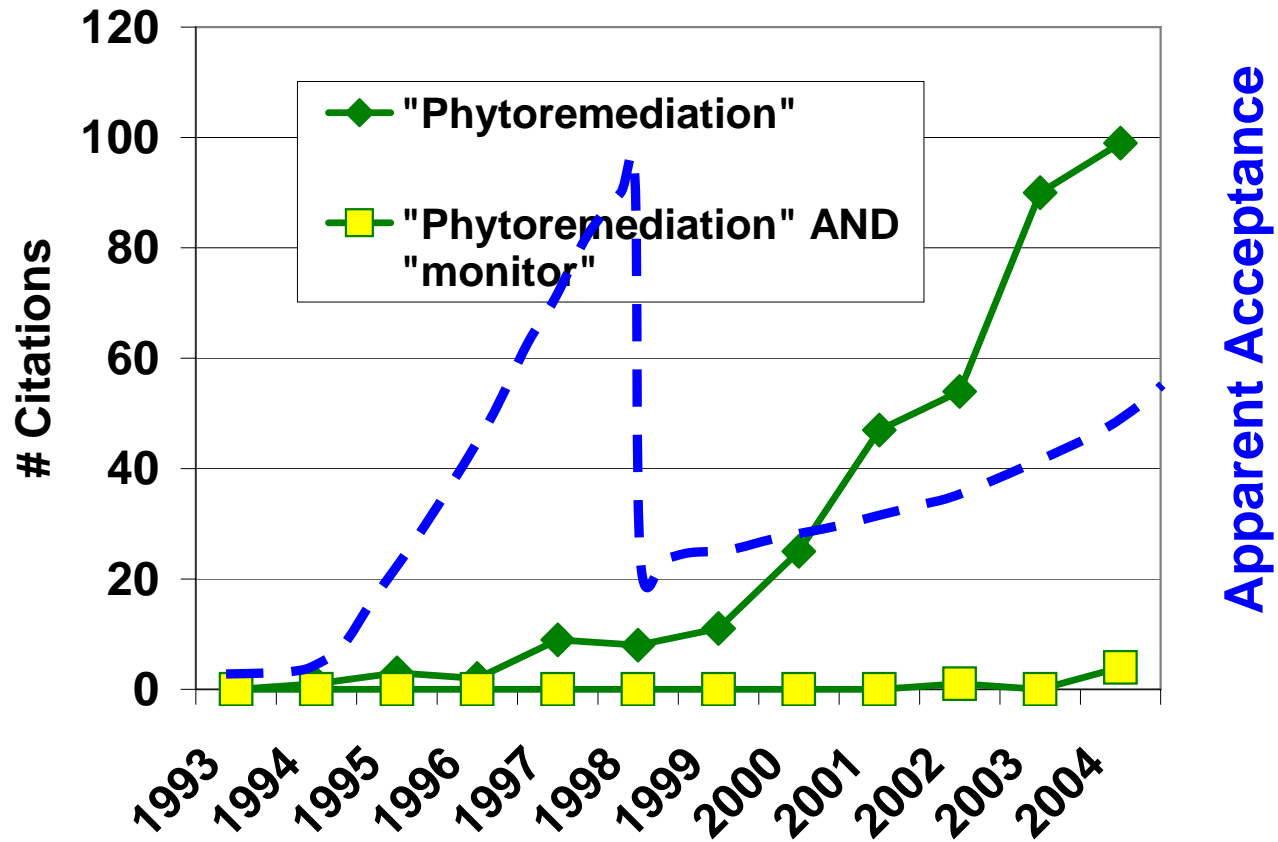
Concepts that can be easily overlooked

- **What resolution do we need?**
 - David Crowley's clever picture analogy
- **A healthy plant may or may not be a good indicator**
 - David Sylvia, Sick looking plants have great mycorrhizal fungi
- **Apply the right approach to the problem at hand**
 - Phytoremediation is complex and claims are easily inflated...
 - It is a “system of systems”
 - It is up to us to keep it grounded



Are we getting there?

PUBMED Citations by Year



Apparent Acceptance





The Tipping Point: How Little Things Can Make a Big Difference - by M. Gladwell

Gladwell explains dramatic change in many fields using epidemiology analogies

Collision of not-so-obviously related events can lead to significant change

Similar to "Liebig's Law of the Minimum" in biological growth

- Rate limiting step
- Governing Process
- Unstable equilibrium to stable equilibrium

What is limiting?
How can we fix it?

Science
Same approach can be used for *understanding* phytoremediation in all its many forms

Application
Can the same approach be used for *appropriately increasing the use of* phytoremediation?

Research and this conference will further answer the science questions

How do we field these technologies?
What convincing arguments can we make?

Can we understand how soil-GW-contaminant-plant-microbe systems converge to go across the tipping point for remediation?

Can we identify what we need to do or know to tip the barriers to phytoremediation use?





Status

- We know it can be successful
- We know much about mechanisms important to phytoremediation
 - And there are MANY mechanisms
- We sometimes can predict where phytoremediation will work
 - And for which contaminants
- We are less good at predicting how long it will take
- We struggle with monitoring
 - There remains a large element of uncertainty
- There are still misconceptions
 - But far fewer over-enthusiastic claims





Lunch Draws Near

Closing thoughts

- Are we there yet?
- Include “metadata” in reporting, leading to:
 - A series of reviews of field studies by “situation” identifying limitations. What worked, what didn’t, and why.
- A “long term” series of phyto-sites with staggered monitoring would make sense
- During the conference - keep in mind the dual tracks of science and application.
 - Talk with those who look at it differently
- You won’t find a better group of scientists and practitioners with which to associate

