

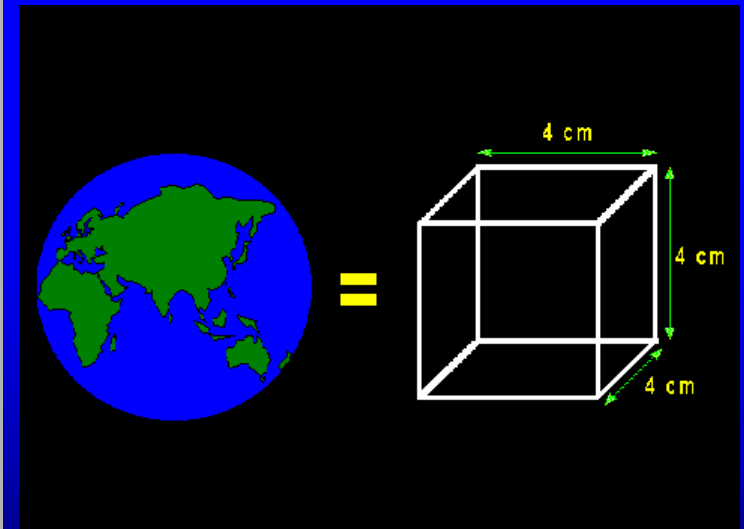
Characterizing Soil Biology: Methods of Soil Analyses

***Hal Collins
USDA-ARS, Prosser***

Soil: Most Complex Biological Community

- *Tremendous population density of organisms.*

<u>Soil Biota</u>	<u>Numbers (in³)</u>	<u>lbs/ac</u>
<i>Bacteria</i>	180,000,000	1500
<i>Fungi</i>	400,000	2400
<i>Protozoa</i>	10,000	130
<i>Nematodes</i>	60	300
<i>Mites</i>	20	100
<i>Earthworms</i>	<1	900



Soil: Most Complex Biological Community

- ***Tremendous population density of organisms.***
- ***Extensive species diversity exhibited by metabolic activities, morphologies, genetics and life history.***

- ***diversity of populations determined by isolation methods indicate 20-50 different phenotypes.***
- ***DNA analyses estimate 4000 different bacterial genomes (Torsvik et al. 1990)***
- ***degradation of a myriad of natural and synthetic compounds***
- ***mediate cycling of plant nutrients***
- ***saprophytic, pathogenic, predatory***

Soil: Most Complex Biological Community

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- ***Complex interactions among soil inhabitants.***

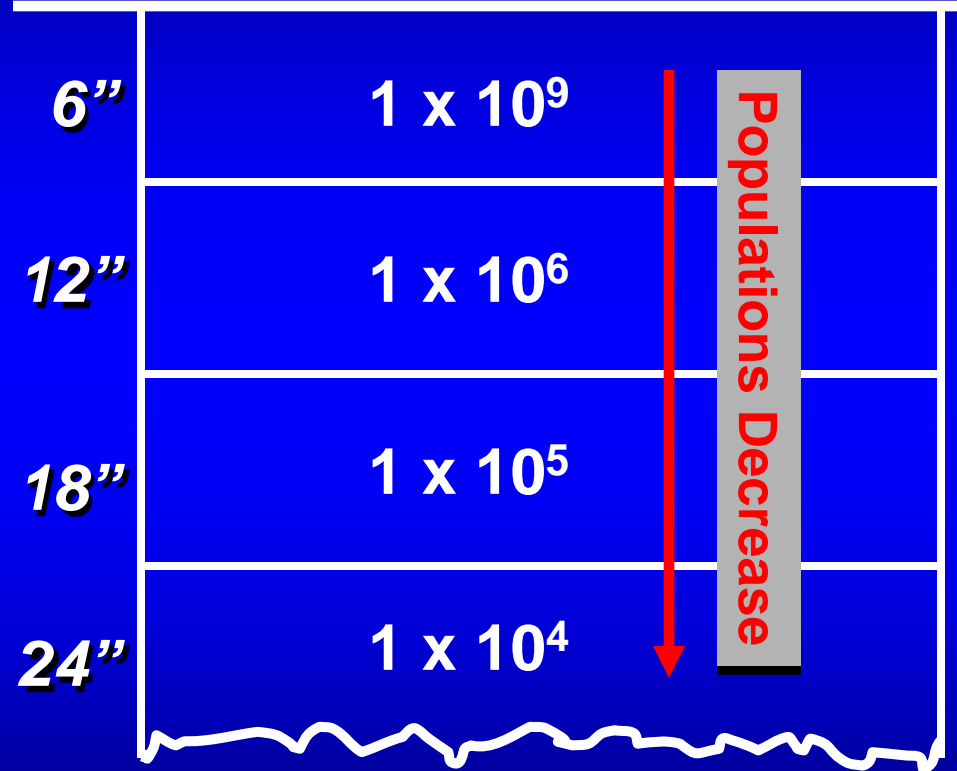
Soil: Most Complex Biological Community

- ***Tremendous population density of organisms.***
- ***Extensive species diversity exhibited by metabolic activities, morphologies, genetics and life history.***
- ***Complex interactions among soil inhabitants.***
- ***Enormous range of physical and chemical conditions in soil.***

Factors Influencing Soil Communities:

•Habitat

Soil Surface



Factors Influencing Soil Communities

•Habitat

•Soil Characters:

- Soil organic matter
- texture
- moisture
- aeration
- temperature
- condition

Organic Matter Characteristics of Agronomic Soils

Soil Organic Matter: 0.5 – 5.0%
5 – 50 tons C/ac

C:N (17:1) 800 - 6000 lbs N

C:P (50:1) 200 - 800 lbs P

C:S (70:1) 150 - 570 lbs S

Microbial Biomass: 1 – 3% of SOC
300 – 2000 lbs C/ac

C:N (5:1) 60 - 300 lbs N

Factors Influencing Soil Communities

•Habitat

- Soil Characters:***
 - Soil organic matter***
 - texture***
 - moisture***
 - aeration***
 - temperature***
 - condition***

- Management Characters:***
 - Crop Rotation***
 - Tillage***
 - Fertilization***
 - Fumigation***

Characterizing Soil Biological Communities

- ***What do you measure?***
 - ***Function or Structure?***
- ***“Snapshot” or monitor?***
 - ***General status of soil biota***
 - ***Change in Management***
 - ***Perceived Loss in Function***
- ***How do you sample?***
 - ***Sampling should reflect either the habitat/ distribution of the target organism.***
 - ***or for function the rooting depth of the crop of concern.***

Approaches to Characterize the Soil Biota

Integrative Methods:

- ***Approach that evaluates the activity of the soil biota in toto without concern for identifying or characterizing individual populations.***
- ***Estimates overall biotic processes or function***

Population Based Methods:

Approaches to Characterize the Soil Biota

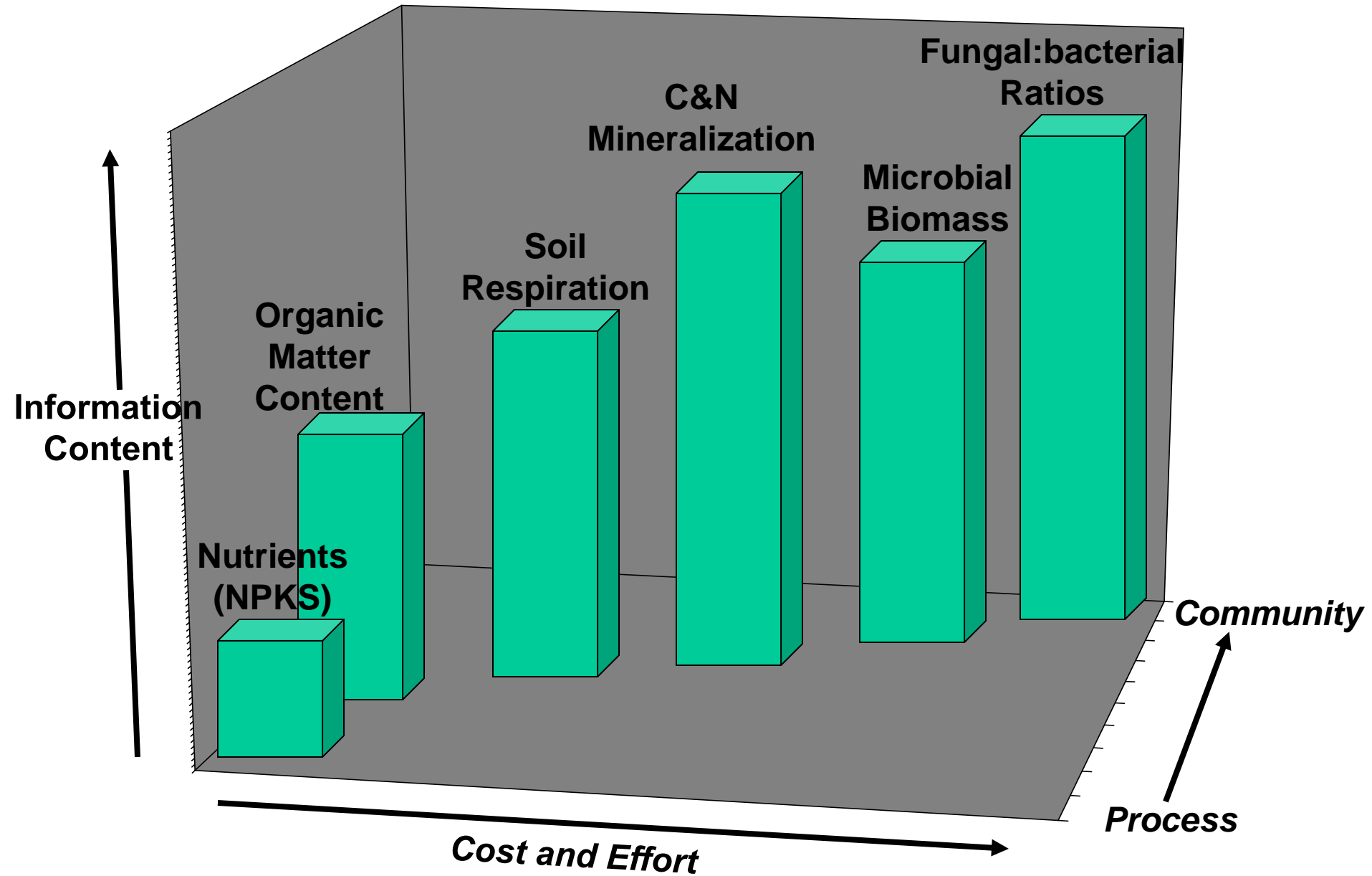
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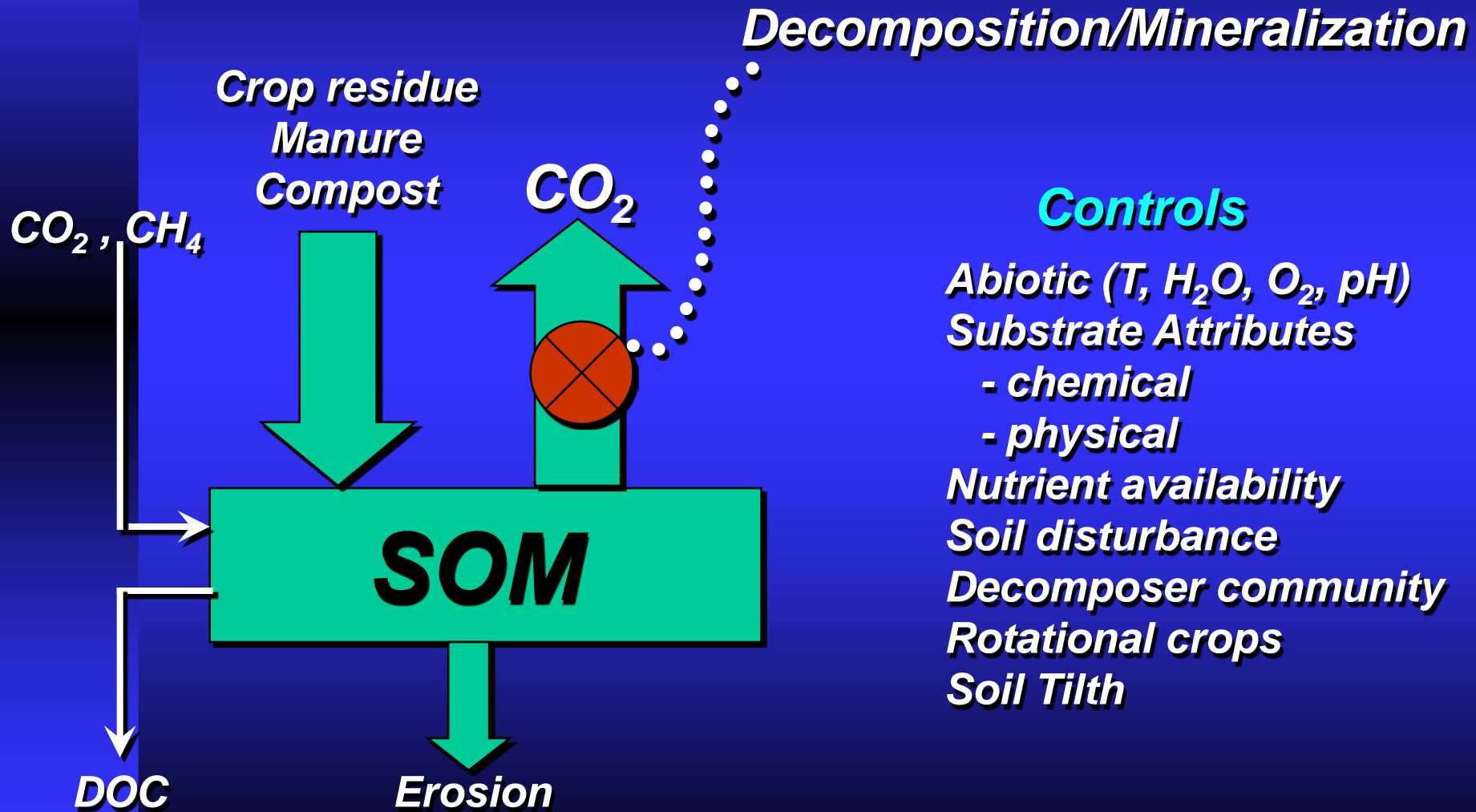
Population Based Methods:

- ***Approach that identifies and characterizes individual populations/communities.***
- ***Methods are based on direct observation and commonly involve extraction protocols.***
- ***Basis of Food web***

Integrative Based Analyses



Cycling of Soil Organic Matter



Approaches to Characterize the Soil Biota

Integrative Methods (Process)

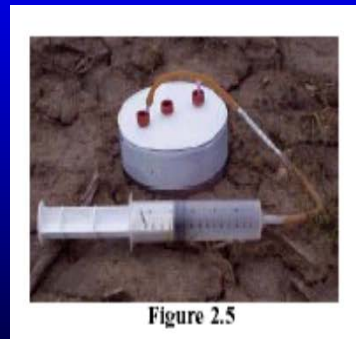
• Soil Respiration/C-mineralization

- Sum of all soil metabolic activities of the soil biota that produce CO_2 .
- The CO_2 produced over an incubation period is used as an index of C available to the soil flora.

• Considerations

- Soil respiration is a dynamic process that varies due to organic addition, soil moisture and temperature.

Field or Laboratory Analyses



Approaches to Characterize the Soil Biota

Integrative Methods

- ***Microbial Biomass*** *It is an important component of soil organic matter that regulates the transformation and storage of nutrients*
- *It comprises the active fraction of SOM containing in their bodies 1-3% of the total soil C and up to 5% of the total soil N.*
- *The microbial biomass mediates all ecosystem functions associated with nutrient cycling, soil fertility, global C change, and SOM turnover.*
- *The size and activity of the soil microbial biomass must be assessed to fully understand nutrient fluxes.*

Approaches to Characterize the Soil Biota

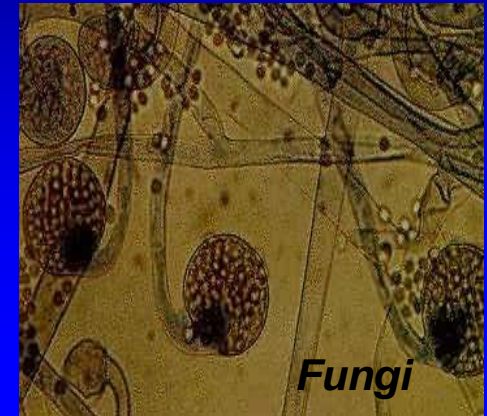
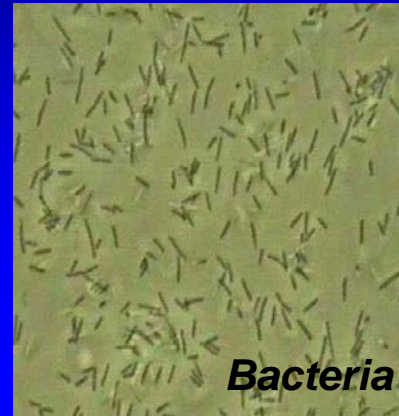
Integrative Methods

- **Microbial Biomass:**

Methods of analysis:

I. Microscopy

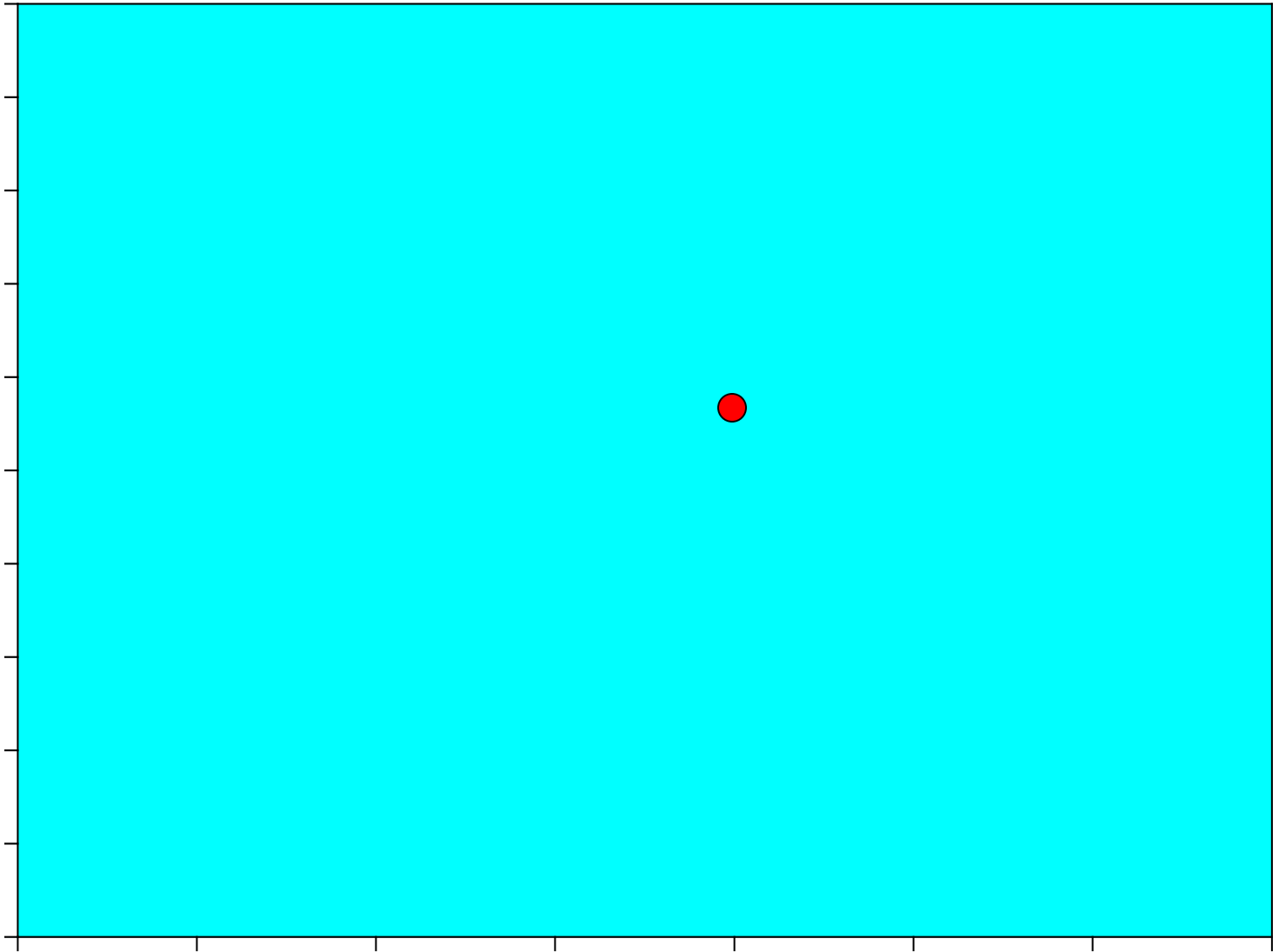
- Serial soil dilution
- Staining and counting microbial cells.



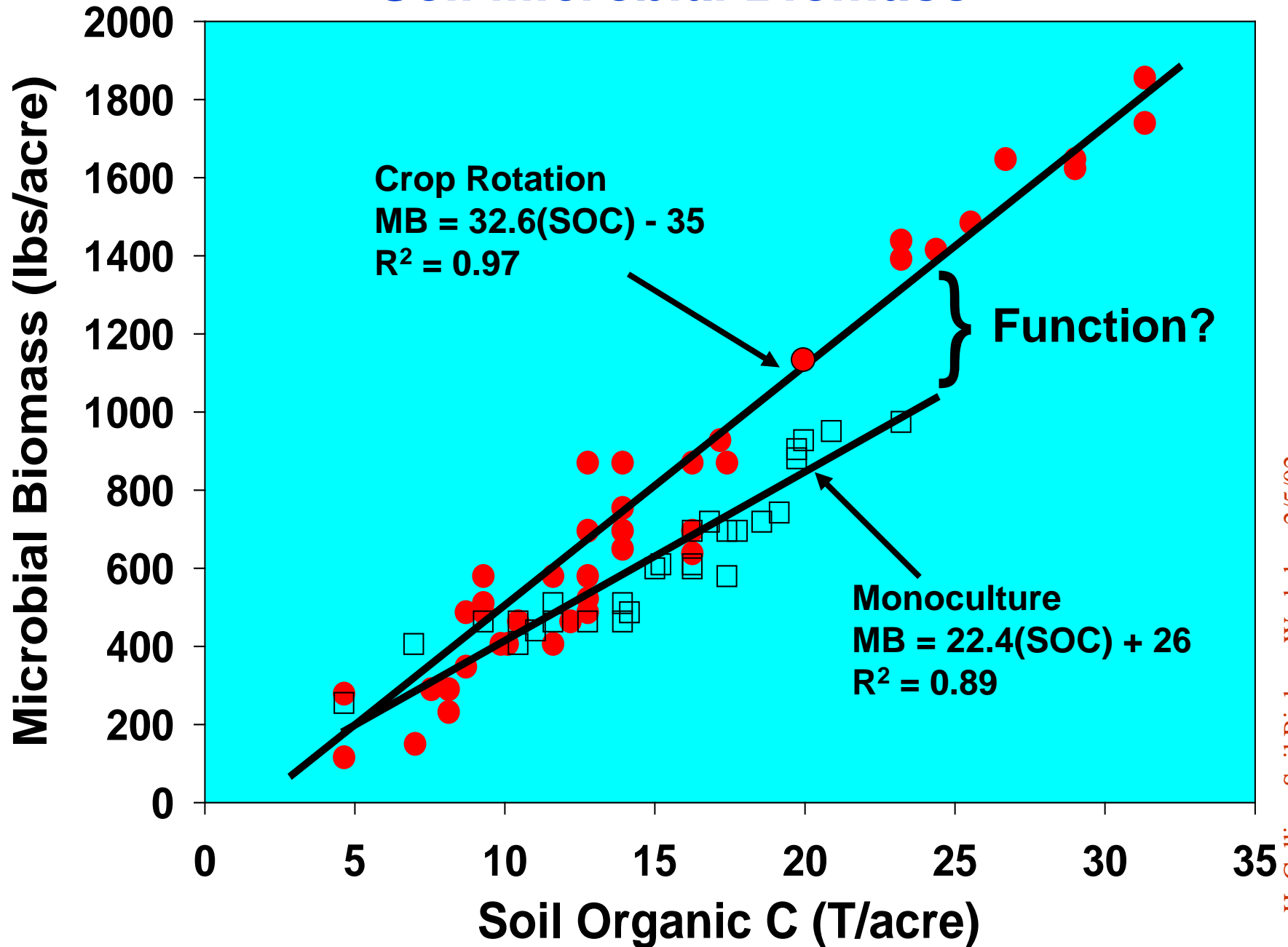
**II. Fumigation/incubation
Fumigation/Extraction**

- Soil samples are fumigated with CHCl_3 .
- Fumigation kills the soil microflora releasing cytoplasm to the soil.
- Soil can either be incubated to convert microbial C to CO_2 or directly extracted.

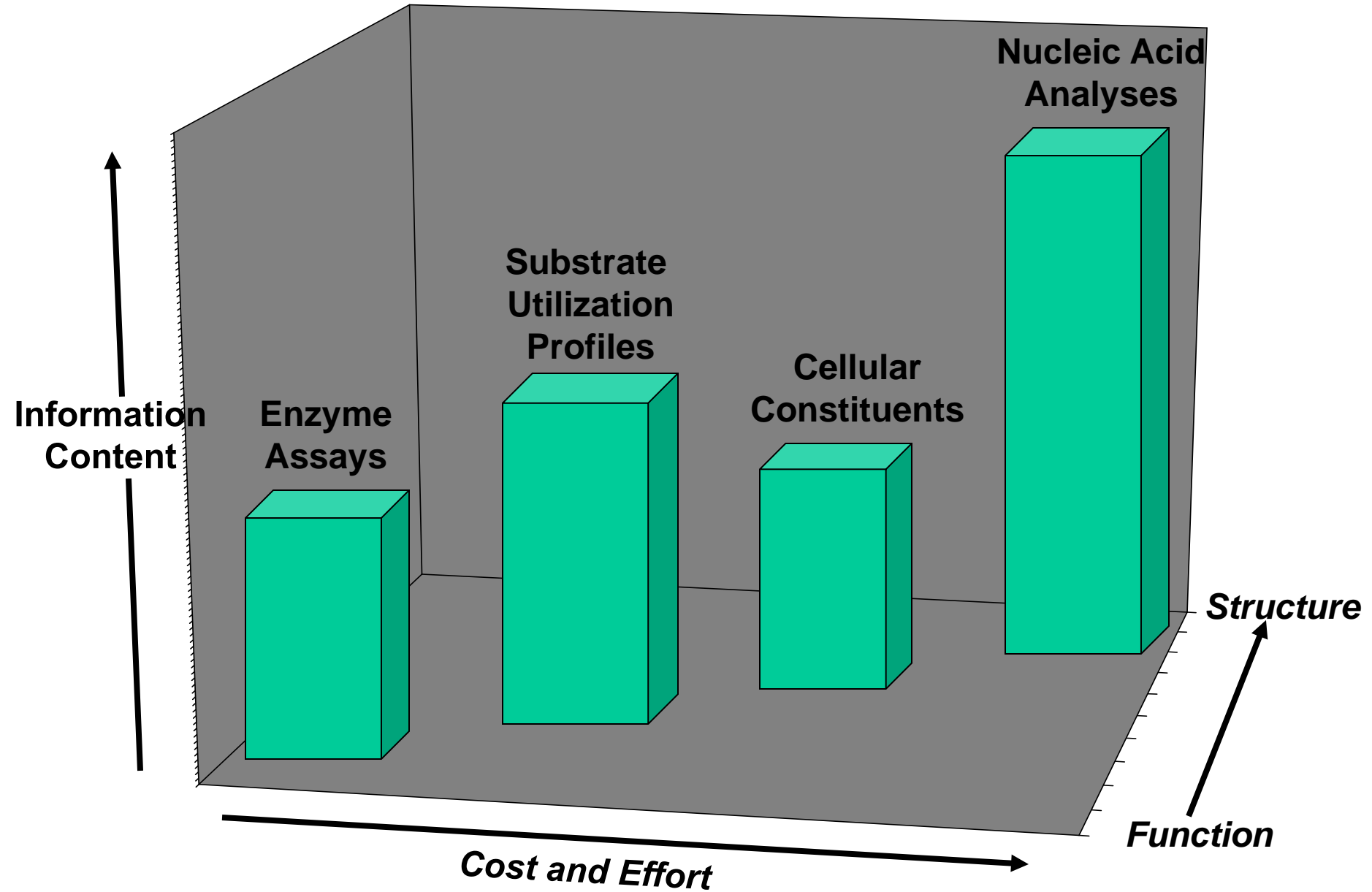
Soil Microbial Biomass



Soil Microbial Biomass



Community Based Analyses



Approaches to Characterize the Soil Biota

Community Based (Process/Function)

- ***Enzyme Assays:***

“All biochemical reactions are catalyzed by enzymes”

- ***Provide functional information about the soil microflora.***
- ***Extra cellular enzymes are released by bacteria and fungi to breakdown organic matter into assimilable forms.***

Enzymes of interest:

Dehydrogenases

hemicellulases

Phosphatases

cellulases

pectinases

arylsulfatases

chitinases

peptidases

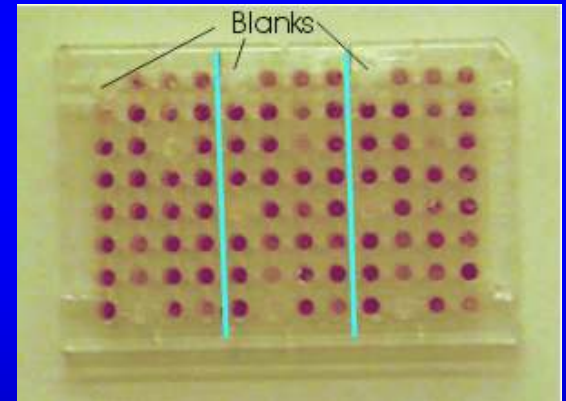
pectinases

- ***Analyses infer relative efforts of the soil microflora to obtain C, N, or P from specific sources.***

Approaches to Characterize the Soil Biota

Community Based Methods (Process/Function)

- ***Enzyme Assays***
 - ***Substrate Utilization Profiles***
- ***Provides information on the functional diversity of soil bacterial communities***
 - ***Soil communities are challenged against an array of C-compounds***
 - ***Ecological significance is difficult to interpret.***



Approaches to Characterize the Soil Biota

Community Based Methods (Composition)

- ***Enzyme Assays***
- ***Substrate Utilization Profiles***
- ***Lipid Analyses***
 - ***Provide information on the phenotypic characteristics of the microflora***
 - ***Based on the extraction and quantification of membrane fatty acids.***
 - ***“Signature lipids” identify taxonomic group.***
- ***Nucleic Acid Analyses***
 - ***Provide information on the genotypic structural composition of the microflora.***

Soil Test Kits



Nutrient Based

\$20 - \$500

pH, NPKS, humus, salinity

Soil quality based

\$500

***pH, nitrates, salinity (EC)
compaction, moisture
soil respiration, texture
Infiltration, earthworms,
water quality.***

Soil Test Laboratories

Soil Fertility Emphasis:

- ***Land-grant Universities***
- ***Commercial Laboratories***

***Analyses Performed: Major plant nutrients, pH
soil organic matter, CEC, texture
tissue testing, water quality***

Soil Biological Properties:

- ***ATTRA – Appropriate Technology Transfer for Rural Areas***

www.attra.org

***Analyses Performed: Total bacteria/total fungi,
Active bacteria/active fungi,
Microbial biomass, Nematodes, VAM
Protozoa, Arthropods, FAME***

Approaches to Characterize the Soil Biota

Resources for Sampling and Methodology:

- ***SSSA Book Series:5
Methods of Soil Analysis Part-2
Microbiological and Biochemical Properties
SSSA Inc., Madison, WI***
- ***Standard Soil Methods for Long-term Ecological Research
Oxford University Press, New York, NY***
- ***ATTRA – Appropriate Technology Transfer for Rural Areas
www.attra.org***

Approaches to Characterize the Soil Biota

Summary:

- 1. You can tell a lot about the size, activity, and function of the soil biota from a few well selected analyses.*
- 2. Soil organic matter is the “fuel that runs the microbial engine”*
- 3. Interpretation of results should be put into perspective to the goals of management as well as how they represent a known database.*