

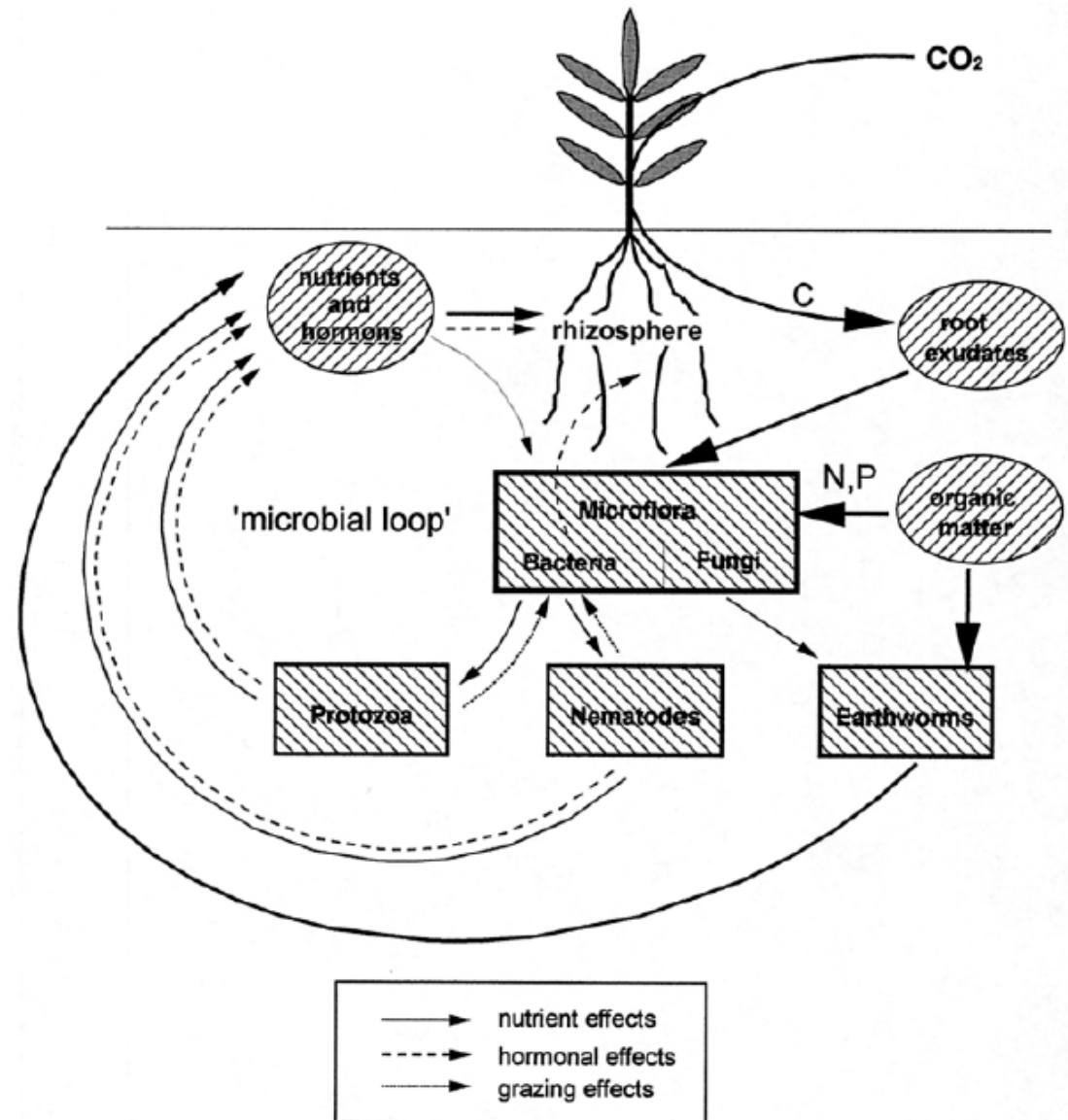
# Impact of functional microbial diversity on soil ecosystem services and assessment thereof

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# Functions of microorganisms in soil





# Functions of microorganisms in soil

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- > turnover of organic matter
- > recycling of nutrients
- > plant growth beneficial microorganisms
- > competition and dilution of microorganisms
- > degradation of organic pollutants
- > food for predators
- > control of plant pests
- > plant pests
- > and more...

- for this a high diversity is required



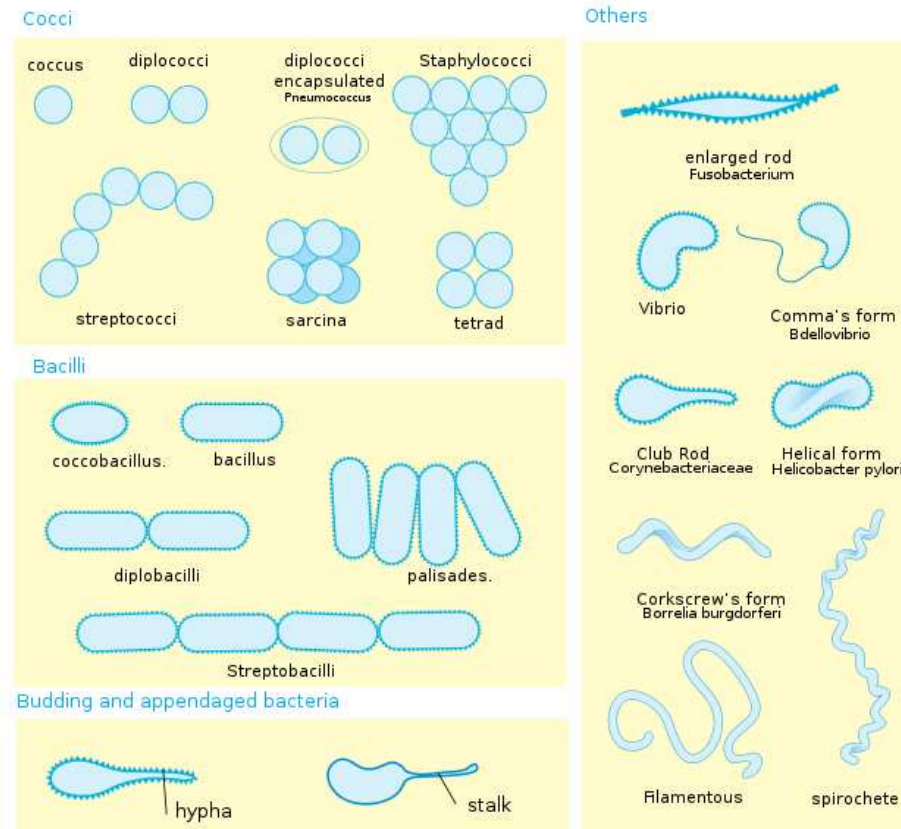
# Diversity of microbial communities

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- › Biodiversity is the variability among living organisms  
.... includes diversity within species, between species,  
and of ecosystems

# Determination of microbial diversity

- > not taxonomy
- > not morphology





# Determination of microbial diversity

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Genetic diversity

DNA

Structural diversity

structural cell constituents e.g Phospholipid fatty acids

Functional diversity: *what they can do at the given conditions.*

mRNA, growth, respiration, enzyme activities

Choice of method ?!



# Selecting biological indicators for monitoring soils

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Ecological relevant biological indicators of soil:

183 candidates – reduced to 21 candidates for different trophic groups

considering soil functions, environmental interactions, supporting habitats and biodiversity

General microbial functions:

- activity capability profile of community
- enzyme potential activity

Method development and standardization required

*(Ritz et al. 2009)*

# Respiration based

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- CO<sub>2</sub> production, measured by GC  
Substrate Induced Respiration (SIR) on multitude  
of substrates
- <sup>14</sup>C-CO<sub>2</sub> measured by scintillation counting
- CO<sub>2</sub> measured by indicator dye  
(Biolog, MicroResp)





# Enzyme activities

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## Extracellular enzyme activities

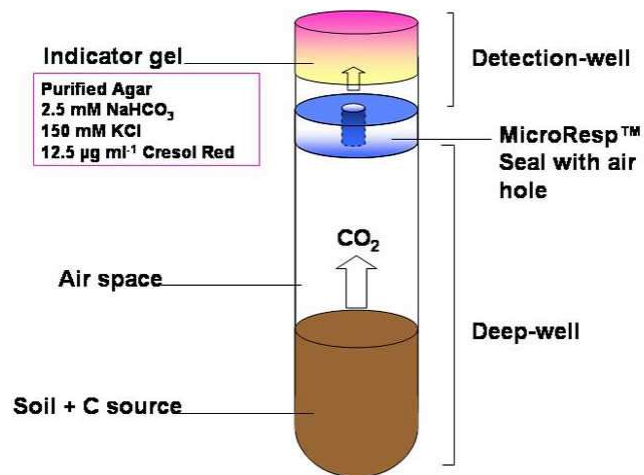
general substrates

fluorescent substrates in microtiter plates

## Bacterial enzyme activities

separate bacteria from soil

# MicroResp



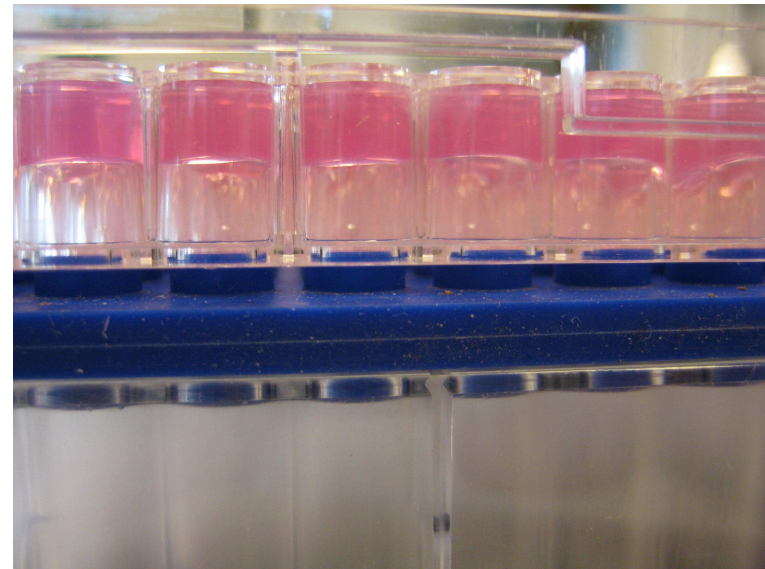
## Colorimetric method

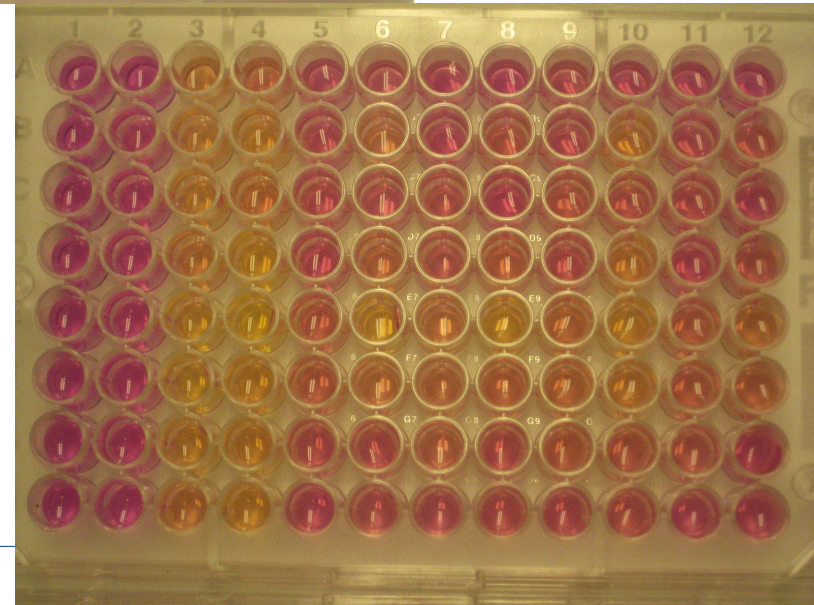
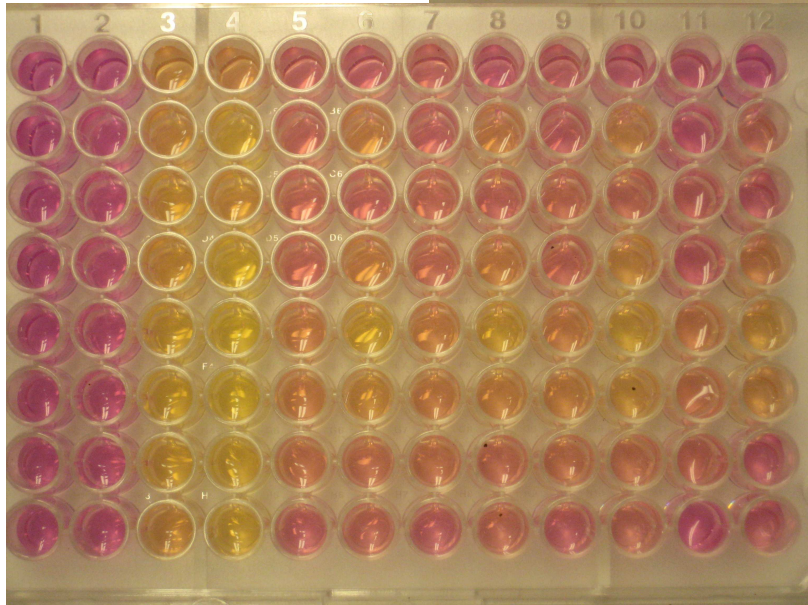
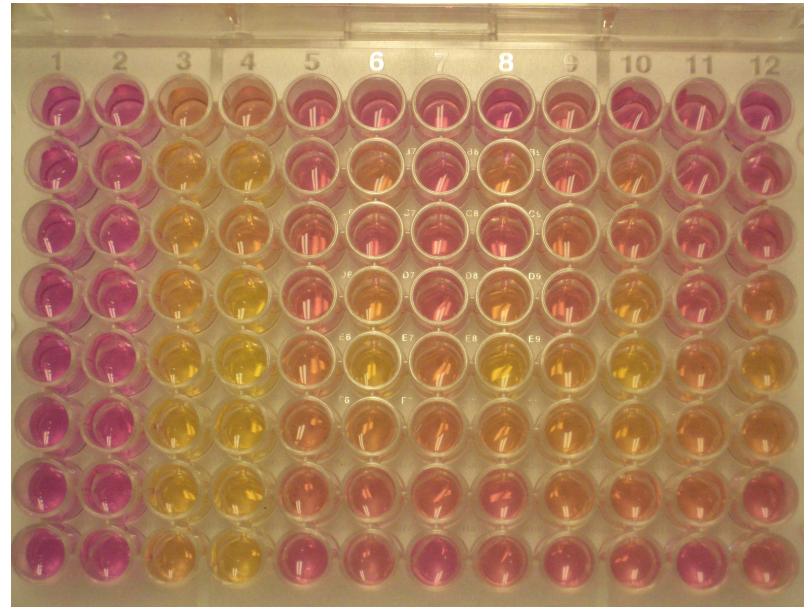
Indicator gel: The cresol red changes from pink to yellow as the pH decreases.



KCl is present to reduce the effect of ionic strength on pH.

([www.microresp.com](http://www.microresp.com))





# MicroResp

	Multi SIR (Degens and Harris 1997)	MicroResp (13 references) <i>(number of substrates identical to MultiSIR)</i>
Carbohydrates	15	19 (9)
Amino Acids	23	17 (13)
Alcohols	5	2 (2)
Amides	3	0 (0)
Amines	7	5 (3)
Carboxylic acids	26	14 (7)
Other	3	6 (2)
Total	82	63 (36)

# Extracellular Enzyme Activity

**Table 1. Role of soil enzymes**

Enzyme	Organic Matter Substances Acted On	End Product	Significance	Predictor of Soil Function
Beta glucosidase	carbon compounds	glucose (sugar)	energy for microorganisms	organic matter decomposition
FDA hydrolysis	organic matter	carbon and various nutrients	energy and nutrients for microorganisms, measure microbial biomass	organic matter decomposition nutrient cycling
Amidase	carbon and nitrogen compounds	ammonium (NH <sub>4</sub> )	plant available NH <sub>4</sub>	nutrient cycling
Urease	nitrogen (urea)	ammonia (NH <sub>3</sub> ) and carbon dioxide (CO <sub>2</sub> )	plant available NH <sub>4</sub>	nutrient cycling
Phosphatase	phosphorus	phosphate (PO <sub>4</sub> )	plant available P	nutrient cycling
Sulfatase	sulfur	sulfate (SO <sub>4</sub> )	plant available S	nutrient cycling

# Extracellular Enzymatic Activity assay

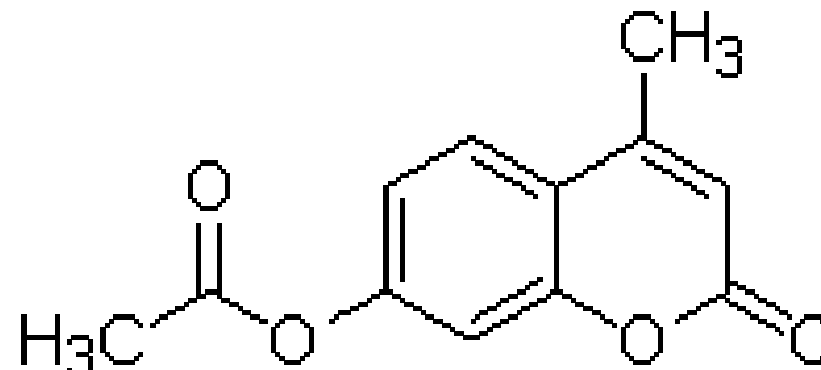
fluorescently labelled substrates (a total of ca. 25 different reported used)  
enzymatic cleavage induce fluorescence

Microtiter based assay with 96 different substrates/replicates/microbial communities

Example: 4-Methylumbelliferyl acetate

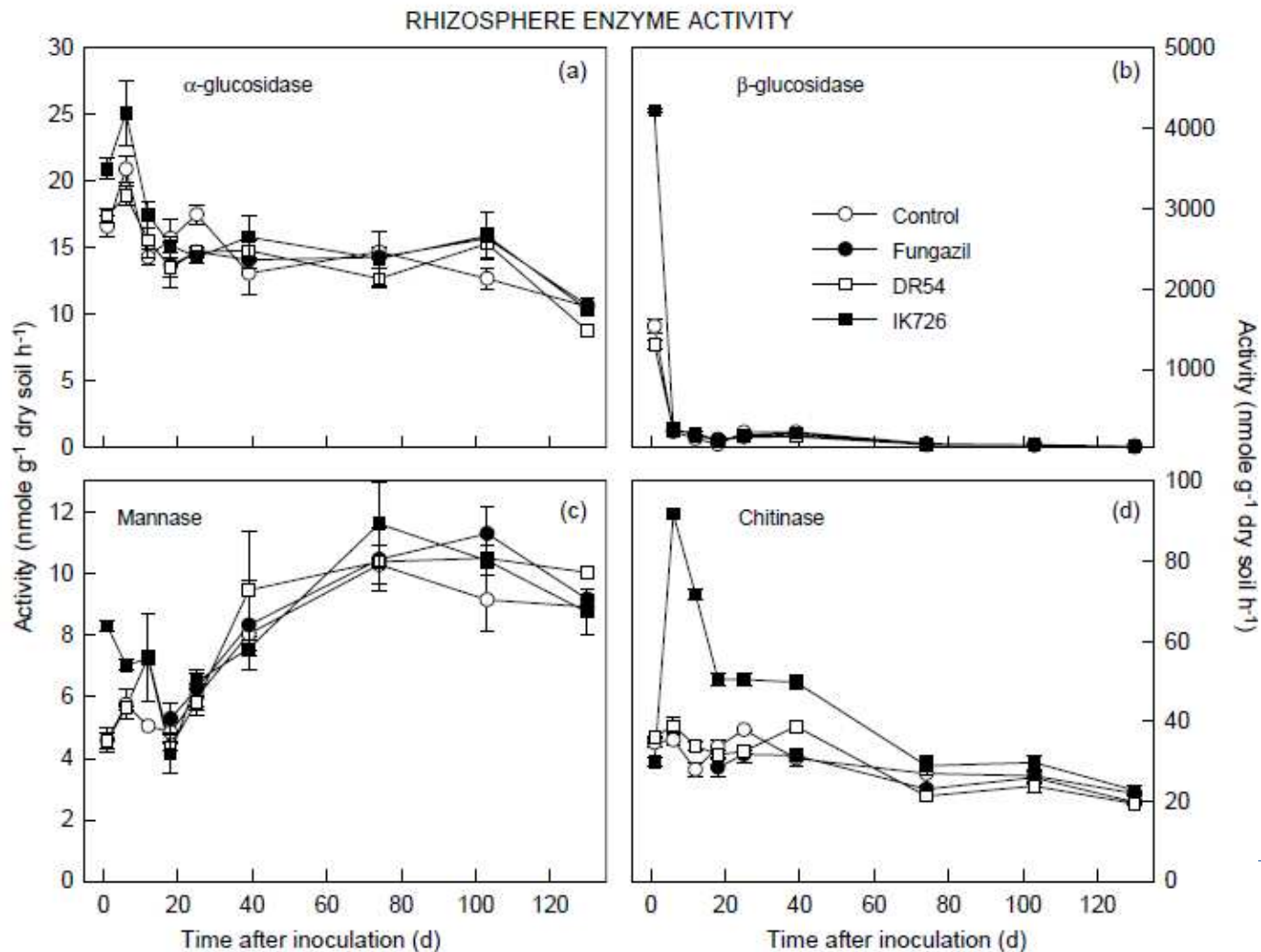
4-methylumbelliferyl acetate + H<sub>2</sub>O  $\rightleftharpoons$  4-methylumbelliferone + acetate

*(MUF substrates)*



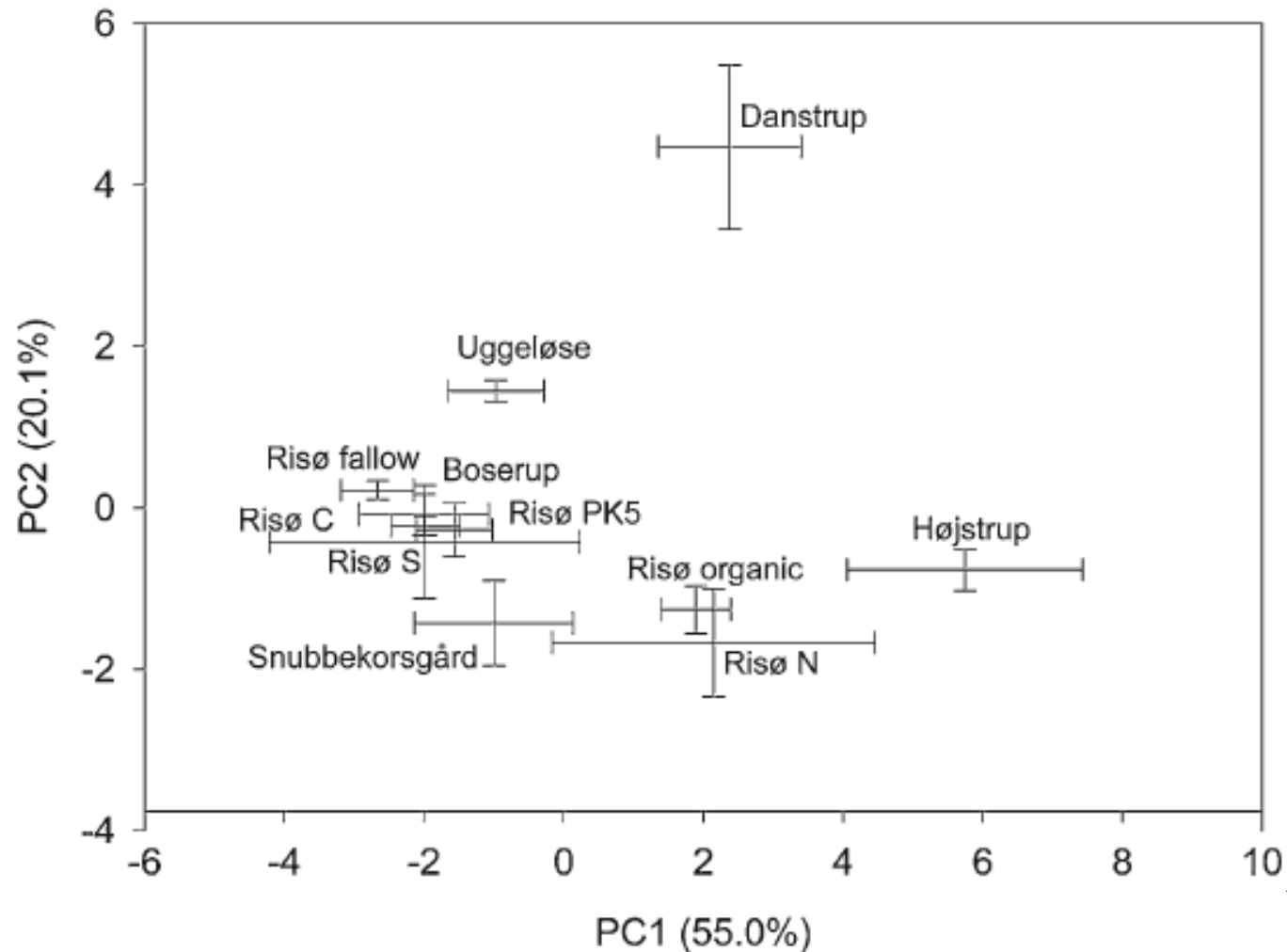
# Extracellular Enzyme Activity in rhizosphere

*A. Johansen et al. / Soil Biology & Biochemistry 37 (2005) 2225–2239*





# Cellular enzyme activity in soil



(Winding and Hendriksen 2007)

Anne Winding

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# European Long Term Observatories

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- › Sweden
  - › The Netherlands
  - › Great Britain
  - › France
  - › Italy, Sardinia
  - › Portugal
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- › Compare and contrast soils and methods to identify bioindicators and develop standard operating procedures for these.



# What can MicroResp and EEA be used for?

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- › track changes (rate/potential) in functions of microbes or functional microbial diversity
  - › input to modelling of soil food web
  - › bioindicator of soil microbial diversity and soil quality
  - › soil quality index
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- › assessing functionality of microbes for providing ecosystem services



# Key ecosystem services affected by functional microbial diversity

## Biomass production

cycling of waste and dead organic matter  
food for predators

## Nutrient regulation

recycling of nutrients

## Pest and disease control

competition  
suppressive soils  
microbial pest control agents

## Green house gas regulation

producers of CO<sub>2</sub>, CH<sub>3</sub>, NO<sub>x</sub> and more  
consumers of CH<sub>3</sub>, NO<sub>x</sub>

## Carbon sequestration

heterotrophic life cycle (mainly)



# Thank you

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