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General Surveillance system for the soil ecosystem

Report of the workshop

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Abstract

General Surveillance system for the soil ecosystem
Report of the workshop

According to European legislation General Surveillance should be conducted to detect unexpected effects of commercially cultivated genetically modified crops on the environment. Genetically modified crops might be cultivated in the Netherlands in the near future. RIVM has asked an international panel of experts to provide advice on the necessary steps and procedures for a GS system in the Netherlands. This report, describing the discussion and conclusions of the panel, will be presented to the Ministry of Housing, Spatial Planning and the Environment. This ministry will decide how GS will be implemented.

The panel focussed on the soil ecosystem because this was an unexplored area. According to the panel the main goal of GS is to protect the functions of the soil which are important for agriculture and nature. Moreover, the panel argued that soil quality should be assessed in relation to the soil users (farmers, nature conservationists, local authorities). In that respect it is important to monitor the soil and to ask the different users to assess the results depending on the location. To judge such results a model was developed which is described in the report. Such a GS system may be complemented with data from the other networks such as the network on ecological; monitoring and satellite observation systems.

Besides this, the panel concluded that a GS system should be based on existing monitoring networks; in the Netherlands this is the monitoring network called Biological Indicator for Soil Quality. In order to make this system suitable for GS three different scenarios were proposed depending on the number and locations of possible future genetically modified crops. The panel also recommended that the data should be collected and stored in a centrally managed database which yet has to be developed.

Key words:
general surveillance, genetically modified plants, soil ecosystem, monitoring

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Rapport in het kort

General Surveillance system for the soil ecosystem
Rapportage van de workshop

Europese regelgeving voor het op de markt brengen van genetisch gemodificeerde gewassen vereist dat er in iedere lidstaat met behulp van 'General Surveillance' (GS) wordt nagegaan of commercieel geteelde genetisch gemodificeerde planten (GGP's) onverwachte effecten hebben op het milieu. Het RIVM heeft een panel van internationale experts om advies gevraagd welke stappen en procedures nodig zijn om een dergelijk GS systeem voor Nederland op te zetten. Op dit moment vindt in Nederland geen commerciële teelt van GGP's plaats maar in de nabije toekomst kan daar verandering in komen. Het panel richtte zich op effecten van GGP's op het ecosysteem van de bodem, omdat dit onderdeel van het milieu nog niet eerder is verkend. De discussies en de conclusies van het panel staan in dit rapport beschreven en zullen aan VROM worden aangeboden. Dit ministerie zal bepalen hoe de GS wordt vormgegeven.

Volgens het panel is het hoofddoel van GS om de functies van de bodem te beschermen die belangrijk zijn voor landbouw en natuur. Vervolgens stelde het panel voor dat de bodemkwaliteit wordt bekeken in relatie tot de gebruikers van het land (boeren, natuurbeheerders en lokale autoriteiten). In dat verband is het belangrijk om de bodem te monitoren en de resultaten, die afhankelijk zijn van de locatie, voor te leggen aan de verschillende gebruikers. Om de resultaten te beoordelen is een model ontwikkeld, dat in het rapport staat beschreven. Een dergelijk GS-systeem kan worden aangevuld met gegevens van andere netwerken die de vegetatie in beeld brengen, zoals het netwerk ecologische monitoring en satelliet observatiesystemen.

Daarnaast concludeerde het panel dat een GS systeem gebaseerd moet worden op bestaande meetnetwerken; in Nederland is dat het bodemmeetnet Bodem Biologische Indicators (BoBI). Om dit geschikt te laten zijn voor GS zijn drie scenario's ontwikkeld. Hierin is rekening gehouden met de verschillende schaalgroottes waarop GGP's worden verbouwd in relatie tot het benodigde aantal meetpunten (van geen, via incidentele tot grootschalige verbouwing). Verder is het panel er een voorstander van dat gegevens worden opgeslagen in een speciale, nog op te zetten database die centraal wordt beheerd.

Trefwoorden:
general surveillance, bodem ecosysteem, genetisch gemodificeerde planten, monitoring

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Contents

Summary

According to EU directive 2001/18/EC, when *Genetically Modified* crops are commercially cultivated a General Surveillance (GS) system has to be set up that should be able to detect effects of GM events that are unexpected. This report describes the discussion and conclusions of an international panel of experts on the steps and procedures which are deemed necessary for the development of a General Surveillance system to monitor the soil ecosystem.
The panel thought it important that monitoring of the soil ecosystem should be part of a General Surveillance system in the Netherlands and that has to be able to detect unexpected effects. For the development of a GS system it is necessary to define protection goals for the soil ecosystem. According to the panel the overarching protection goal is protection of soil quality. Soil quality may be linked to ecosystem services and the parameters for monitoring by introducing a stakeholder participation model. Such a system may include various stakeholders or users of the soil such as farmers of nature conservationists. For the design of a sampling strategy three different scenarios are described that depend on the number of areas or the size of GM crops cultivation sites. It was regarded important that the power and resolution of the proposed soil monitoring system will be statistically analyzed. The GS data should be collected and stored in a database managed by a Central Reporting Office. Impacts exceeding normal variability of the soil ecosystem should be judged in relation to land usage by a board of stakeholders. A GS system may include data from the 'Netwerk Ecologische Monitoring' and earth observation systems as well as other data resources (e.g. farm questionnaires or reports form organisations involved in nature conservation).
Data from soil measurements, earth observation, GM crop registration and possibly farmer questionnaires should be compiled by a Central Reporting Office in GIS based data base.

1 Introduction

According to EU directive 2001/18/EC, when Genetically Modified (GM) crops are commercially cultivated a General Surveillance (GS) system has to be set up that should be able to detect effects of GM cops that are unexpected, i.e. *that are not expected based on the risk assessment of the GM event* (Anon, 2001). Therefore GS should be in principle unfocused and be able to provide an overview of effects that may manifest themselves on the long term or short term, inside or outside the GM cultivation area, and may occur in the 'above ground' ecosystem or in the 'below ground' soil ecosystem.

The EU directive 2001/18/EC does however not specify in detail how such a General Surveillance system should be set up. In the Netherlands it was decided that the notifier should conduct GS in the GM fields while the government will also conduct GS outside the GM fields. So far, only some Member States initiatives have been taken to develop guidance for GS. This guidance is only focused on the 'above ground' parts of the ecosystem; GS of soil ecosystem is so far an unexplored area.

The main dilemma in developing a GS system is that it is fundamentally a program without clear monitoring goals and is designed to support management decisions. Observations need to be made in a scientific way and evaluations should be based on scientifically sound arguments, but thresholds and limits have to be set by regulatory bodies.
The GMO Office in the Netherlands is currently investigating the possibilities for implementing GS in the Netherlands. A project was set up to explore and investigate the possibilities and necessary procedures for developing a GS system for the soil ecosystem. This project is financed by the Strategic Research Program of RIVM and consists of several activities. One of these activities was to organise an international workshop to discuss with a number of experts the possible incorporation of soil ecosystem monitoring in a GS system. This report describes the outcome of the discussions and conclusions of the workshop.

The participants were invited to discuss the feasibility of setting up a GS system for soil ecosystems. The outcome of this workshop will consist of a set of criteria and procedures and recommendations for choosing indicators, the sampling strategy and the way to interpret the data for a GS system for the soil ecosystem.

To structure the discussions of the workshop a scheme was made showing the major issues and questions for GS of the soil ecosystem (see Figure 1).

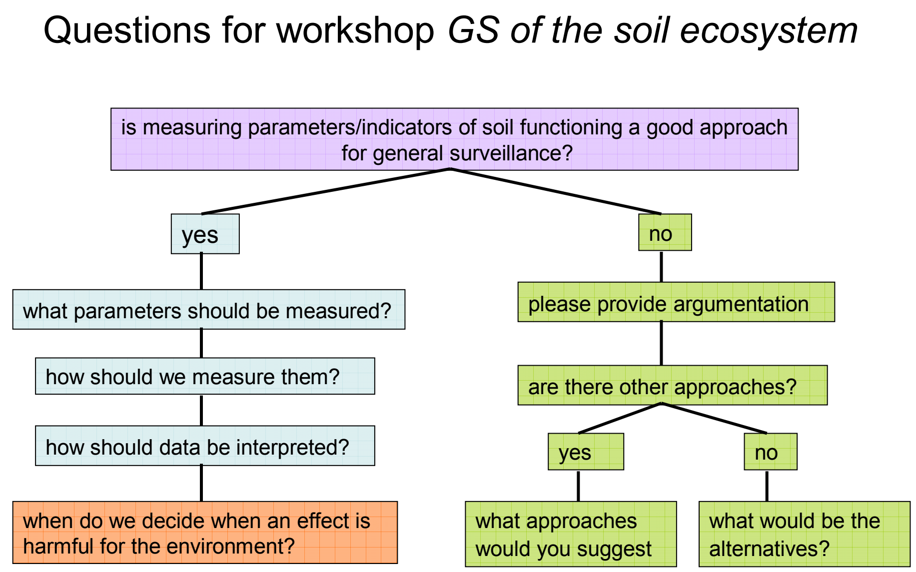

Figure 1. Scheme with the major issues and questions related to the development of a soil monitoring system as part of a GS system in the Netherlands.

The conclusions presented in this report are based on the following questions:

- Is direct measurement of parameters/indicators of soil functioning a good approach for General Surveillance. If not what is the argumentation?
- If so, what parameters should be measured?
- How should they be measured?
- How should data be interpreted?
- On what basis can it be decided that an effect is harmful for the environment?
- Are there other approaches for GS of the soil functioning?
- If so, what approaches would you suggest?
- If not, why not, and what would be the alternatives?

These questions are also used as headings in this report to provide a logical framework to describe the discussions and conclusions of the experts involved in this workshop.

The development of a nationwide GS for the soil ecosystem is a scientific challenge. To start the discussion it was bluntly postulated that most currently used methods to analyze the soil ecosystem in existing routine soil monitoring programs do not provide data that can be used to detect harmful effects. In the discussion we focused on the potential tools for soil ecosystem monitoring and their value for GS.

2 Discussion of the questions regarding soil parameters

2.1 Is measuring parameters for soil functions a good approach?

To start the discussion Boet Glandorf of the office for Genetic Modification at RIVM gave a presentation on the concept of GS and how the EU directive is interpreted. To provoke reactions of the participants she stated that measuring soil parameters is not useful if one cannot interpret and assess the data as being harmful or not. GS was also presented as ‘hypothesis free’, i.e. not driven by a hypothesis based on any GMO. Most participants did not agree with this statement. Monitoring and collecting data should be disconnected from the interpretation phase. Moreover, the participants made several critical remarks with respect to the statement that GS is *hypothesis free* and that GS should monitor *harmful* effects.

First of all: monitoring on a hypothesis free basis is not possible because the target of the monitoring is poorly defined. The soil ecosystem is too complex to monitor completely. Therefore, it is inevitable that a soil monitoring system needs some focus. Focus may be achieved by for instance specifically zooming in on the most vulnerable or exposed species or on the most important processes or functions of the ecosystem or on locations were effects are likely to occur. GS can not be hypothesis free; the hypothesis may be the potential disturbance of the ecosystem. The monitoring program has to be focused on the most relevant species, in relation to commercial cultivation of a GM crop. For instance, when a Bt maize cultivar is cultivated it makes no sense to perform monitoring without any focus. There should also be a focus on the location(s) where the GM crops are cultivated and on the species that are most likely exposed. We will need a similar approach to that used for post market monitoring of pharmaceuticals. It is important to define first what one wants to protect and to then develop a system monitoring whether the protection goal is affected in any way.
Secondly, it was concluded that it is not useful to monitor for harmful effects since it is not known what harmful is and experts can not predict and evaluate a priori all the possible effects that may occur. There is a need to focus on the functions we want to protect. Moreover, harm is not a scientific concept and an effect may only be qualified as harmful after careful assessment of the data involving various stakeholders. Scientists will be mainly involved in data collection, in providing ecological relevant advice and in the process of developing acceptable levels of GM impacts for the decision makers. Other stakeholders will have to determine which functions should be protected. Examples of such

stakeholders are for instance farmers, society and national or regional authorities or land managers from nature reserves. When impacts of GM crops are detected that exceed the previously defined acceptable levels decision makers may be advised by independent scientists with statistical and ecological knowledge to interpret whether these effects are statistically and biologically relevant. In order to prevent any bias data collection should be clearly separated from data interpretation. There was also a general agreement on the fact that monitoring is important, it is essential to provide trust to the citizens that the government is in control of the situation and the data that are generated are scientifically important to increase our understanding of the dynamics of the soil ecosystem and to build up a base line that can used in the decision making process.

After some discussion it was decided not to use the terms. ‘hypothesis free’ and ‘harmful’. The following description for GS was drafted:

Conclusion 1: Monitoring the soil ecosystem should be part of General Surveillance and should be designed to detect unexpected effects.

Other issues raised were that we should learn from the approach used with pharmaceuticals: 1) first define protection goals, 2) than detect an effect related to the protection goals 3) interpret the data. It was also agreed upon that we should base the soil monitoring on existing network in the Netherlands (COGEM advies, 2005) such as the BISQ (Biological Indicator for Soil Quality; Dutch acronym: Bobi) project (see Box 1) or other initiatives.

> The aim of the Biological indicator for Soil Quality program (BISQ or Bobi) is to acquire knowledge of effects of soil type and management on diversity and functioning of soil organisms and mineralization processes and to develop biological indicators for soil quality
>
> Biological indicators for soil quality are measured in the framework of the Dutch Soil Quality Network. The network covers the main types of soil and land-use in the Netherlands. It consists of 10 combinations of soil type and land-use with 20 replicates per category, making a total of 200 sites. The replicates are mainly conventional (intensive) farms. In addition 50 to 100 sites from outside this network are sampled, for instance biological farms or polluted areas which are supposed to be good and bad references, respectively. Each year two categories are sampled (40 sites plus reference sites). Thus it takes five years to complete one round of monitoring.

Box 1. Description of the BISQ program within the Dutch Soil Quality Network

Then the question was raised what the protection goal should be and which key soil functions are important for this protection goal. It was proposed that we could monitor hundreds of functions by using micro-arrays on a biochip. However, most participants agreed that this technology is not ready for standard application. It may be more useful to simply monitor parameters or indicators proposed by international committees of experts. There are a number of different lists with indicators of parameters for soil monitoring. The question that was then raised is: ‘do we need all this information from all these parameters?’ It may help to define what functions one wants to protect in order to make a useful selection of parameters to monitor. This brings us again to the concept of protection goals. First a decision should be made to define what the protection goal is and then it should be relatively easy to select parameters that provide indicators of the status of the selected protection goal. Soil quality may be the overarching protection goal for GS. However, this is a very broad concept and it needs to be further defined and supported by the relevant life support systems that constitute the important basic functions of the soil. All participants agreed that the as a first step in setting up a GS system the protection goals should be defined. It should however, be taken into account that soil is a complex system and we should be very careful to explain what is feasible to measure and what the limitations of these methods are.

Conclusion 2: It is necessary to define protection goals for setting up a monitoring program for the soil ecosystem.

Another question that was raised is: should one focus on agricultural ecosystems only? This question was negatively answered by a number of participants: they were of the opinion that both nature and agricultural ecosystems should be part of a GS system. It should be noted that the farmer will be asked by the seed companies to monitor his own fields with GM crops. This is usually done in the form of questionnaires. In the Netherlands, the government is responsible for monitoring outside the GM cultivation area. However, GMO fields may be included in government GS programs, e.g. as a ‘positive control’. After having discussed the basic principles for GS, the next focus was on which parameters should be measured.

2.2 What parameters should be monitored?

The basic question to answer was ‘what should be monitored?’ Based on the outcome of a previously drafted questionnaire (see Annex 1) a list of potential parameters was discussed. It was stated that one

may either choose a long or a short list of parameters, but that it will be impossible to measure everything everywhere. Choosing the right parameters is a difficult issue to solve, because we do not know what exactly the budget will be and what will be practical and cost-effective. The discussion started with the question, ‘what is the most important function of soil?’ The participants could not easily agree on this. Nutrient or C and N cycling may be one of the most important soil functions. The microbial community responsible for N mineralization plays a key role in nutrient cycling and may be monitored. Changes in this group may indicate effects on nutrient cycling. However, such an indirect way of monitoring only provides indications and not proof that nutrient cycling is impaired since it is not yet possible to deduce functional information from community structure. Therefore, it was argued: ‘why should changes in microbial communities be measured when it is also possible to do direct measurements?’ Since knowledge on many microbial communities and their functions is lacking, it is better to perform direct measurements of certain functions. Similarly, biodiversity was proposed as an important parameter. However it is very difficult to accurately determine biodiversity, moreover, the consequences of biodiversity changes for soil functions such as C cycling or N mineralization are not clear. All participants agreed on the fact that the modern (molecular) methods for microbial community analysis are currently not suitable for routine monitoring. Although these molecular approaches are suitable to assess microbial diversity, they are not suitable for monitoring soil functioning since the relation of diversity data with soil functions are still not understood.
The application of classical measurements, such as determination of biomass of microbial C and N concentrations seems more useful for routine monitoring purposes. In this respect important criteria for the selection of methods are sensitivity, specificity, robustness and repeatability and our capability to interpret the data. Using micro-arrays one can screen more than 10,000 genes in samples containing microbial DNA in one analysis. Such biochips may be an excellent tool for future monitoring, however, currently such chips can not be routinely applied since they lack sensitivity and robustness, and moreover, there is a lack of knowledge to efficiently interpret the data. The tentative conclusion was that one cannot simply draw up a list of parameters to measure important soil functions. The list of parameters should be based on the protection goals and the most important ecosystem functions that are responsible for the protection goals, e.g. for soil quality.
Therefore it was decided to define first the protection goal and list the most important soil functions related to this protection goal. For this purpose first a connection has to be established between the protection goal with these possible parameters. For most participants it was not straightforward how this connection could be made.

After having agreed that the protection goals need to be defined first, a number of participants mention soil fertility as the most important goal. However, soil fertility is mainly important from an agricultural perspective and not always relevant for nature. All participants agreed upon the fact that GS should both focus on agriculture and nature. Since we should take both into account, the overarching protection goal was eventually determined as protection of soil quality.

Conclusion 3: The overarching protection goal should be protection of soil quality.

It was agreed that soil quality should be the overarching protection goal. But how could one derive a list of attributes defining soil quality and how could one derive a list of parameters able to serve as indicators for these attributes? It was suggested that this can be done by selecting the most relevant ecosystem services for this protection goal. Ecosystem services are important functions from a human perspective, for instance the micro organisms in soil should be able to break down organic matter and to provide nutrients to the plants, they should suppress plant diseases and regulate water retention and drainage (3). In such a way scientific methodology is linked to management decisions and values. A description of ecosystem services relevant for soil quality is provided in Box 2.

1) Soil fertility

This is an integrated aspect of the production functions of the soil important agriculture and nature.

a. nutrition status; deliver and retain nutrients for plants
b. soil structure; retain a good soil structure enabling plants to develop a health root system
c. disease suppressiveness; the natural ability of the soil to suppress plant diseases

2) Resistance against stress and adaptability

Soil is often used for one purpose only. It is important that the soil has the ability to resist to threats and to restore itself after stress of natural of human origin.

a. resistance against stress
b. adaptation and flexibility

3) The soil as buffer and reactor

The soil plays an important role in the processes important for the whole ecosystem including the atmosphere, surface water, groundwater, atmospheric transport, deposition etc. In soil may processes are coupled to these compartments.

a. fragmentation and mineralization of organic matter; the ability to degrade organic matter and retain a stable fraction of organic carbon in soil.
b. attenuation; the ability of soil to degrade polluting compounds
c. water regulation; the ability to take up and transport water allowing health plant growth
d. climate functions; the ability to buffer and influence the climate by for instance influencing temperature and moisture of the air.

4) Biodiversity

Protection of the structural, genetic and functional biodiversity is strictly speaking not an ecological service. However, it is regarded as an intrinsic value of the soil and therefore important for the use function of soil. It is also assumed that there is a positive relation between biodiversity and soil health.

Box 2. Description of the ecosystem services relevant for soil quality (Leemkule, 2001; Rutgers et al., 2009).

The most relevant ecosystem services could be selected by a group of stakeholders according to a stakeholder participation model (Figure 2). In such a model the land users, which can be either farmers, land managers or representatives of national or regional authorities, are invited to come together and rank ecosystem services from high to low priority. It is up to the land users to determine which ecosystem services are the most relevant from their point of view. Such a ranking can be very different for the various stakeholders, for instance farmers will give priority to ecosystem services related to production while nature preservationists may think that biodiversity and climate functions are the most important for relation to soil quality (Rutgers et al., 2009). After such a ranking, a connection can be made with parameters that can be measured and that are relevant for the ecosystem services. In Figure 2 this system is schematically illustrated.

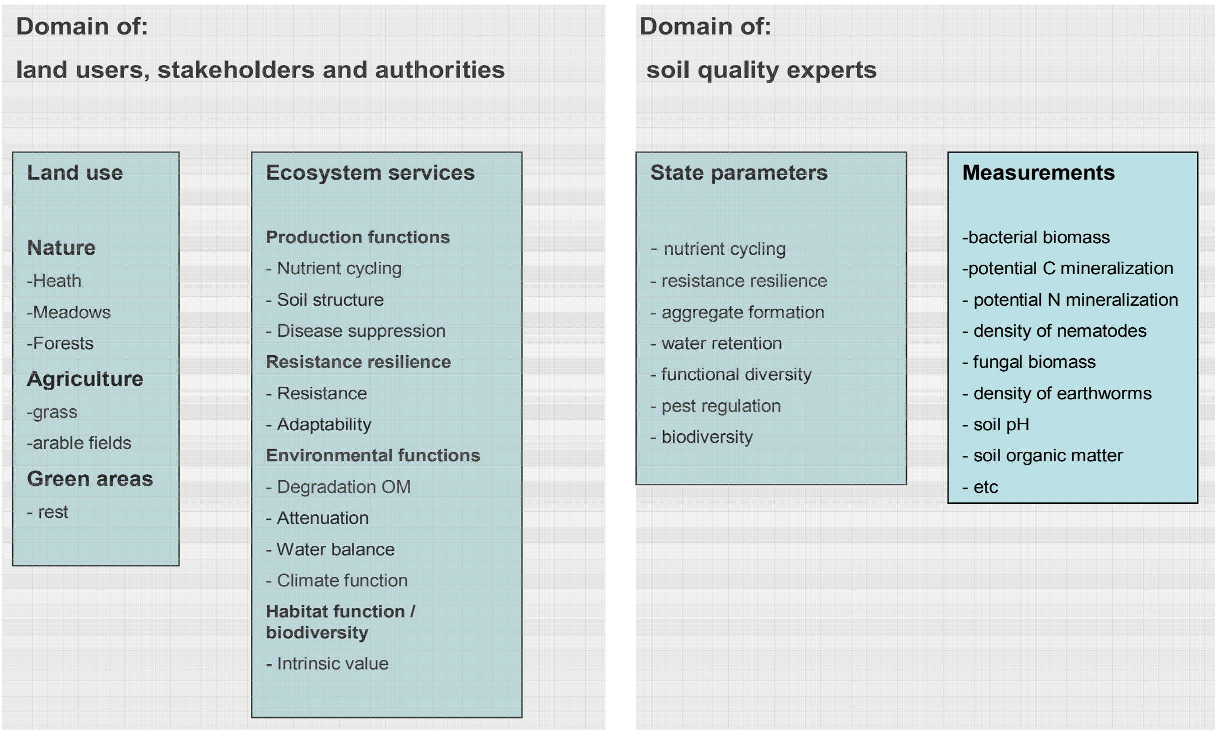

Figure 2. Schematic representation of the stakeholder participation model. This model links the overarching protection goal, 'soil quality', to ecosystem services and a number of measurable soil parameters (Rutgers et al., 2009).

The left domain (Figure 2) is that of the land users and authorities, depending on the land use they determine which ecosystem services are the most important for them, in fact they rank the services from high to low priority. The right domain belongs to the soil experts. In the left pane important soil functions are described and in the right pane measurable parameters are listed (not complete).

When these parameters are determined they are linked to the state parameters (parameters of soil functions that can be measured and provide information on the soil ecosystem) and translated to ecosystem services (for relations see also Figure 4). Based on this methodology the stakeholders can compare the results of a specific soil site with reference locations in space or time and decide if possible effects are acceptable or not. The sensitivity of such a system will have certain limitations and it should be made very clear to the government and the public what the limitations of this approach are, what may be detected and what not.

Conclusion 4: To link the overarching protection goal to ecosystem services and to parameters for monitoring, a stakeholder participation model is suggested that includes various stakeholders and networks.

2.3 How should parameters be measured?

Deciding on sample size, frequency and the number of locations is very difficult; there are many different soil types, land uses and large fluctuations in soil ecosystem dynamics in a small country as the Netherlands and the available budget will ultimately determine the maximum resolution. Within the Biological Indicator for Soil Quality (BISQ) project (See also Box 1 and Figure 3) samples are taken in spring when the (micro)organisms are becoming active and the soil is not yet too dry. Moreover, a practical aspect is that farmers do not like scientists to take samples and disturb their crops during the growing season. Within BISQ, samples are taken at the farm level, which means that samples from soils with different crops and for different uses are pooled (Schouten et al., 2001). Such an approach reduces the sensitivity to detect for instance the effects of growing different crops. On the other hand it improves the possibility to address effects of the land management and the complete cropping system on the soil because different crops are always part of a rotation system. In BISQ, farms are sampled every 5 years. The participants generally considered this to be insufficient if the number of GM fields is limited. Small differences may disappear because of different crops growing on one farm or effects may remain unnoticed. Moreover, a 5 year period between sampling dates may be too long for GS. GS is after all an early warning system for potential environmental harm. It may thus take more than 10 years to get data that may indicate small effects.

Currently, within the BISQ network 200 locations are sampled in the Netherlands (Figure 3) was considered to be a huge effort to sample and analyze all 200 locations at a yearly frequency. Besides that one should take into account that currently no GM crops are cultivated in the Netherlands and it may be necessary to increase the number of locations by adding new

Figure 3 Sampling locations for the BISQ project in the Netherlands (Schouten et al., 2001).

locations on which GM crops are cultivated. Sampling a few extra fields with GM crops every year may be to be feasible considering the available budget. But what if GM crops are cultivated all over the Netherlands? Given the available men power and budget it will become impossible to manage and analyze samples in and around all GM fields. In that case one should devise a new (more random) monitoring scheme. So, when only a few fields of GM crops are cultivated the government could be advised to monitor in and outside these fields with a yearly frequency. Statistical planning is essential to define the degree of resolution in relation to sample frequency and locations. It may clarify which threshold levels can be detected with a given statistical power and whether efforts are worth trying facing the natural fluctuations. Eventually consensus was reached that we need to define three different monitoring scenarios depending on the size of the cultivation area of GM crops (see also Figure 4).

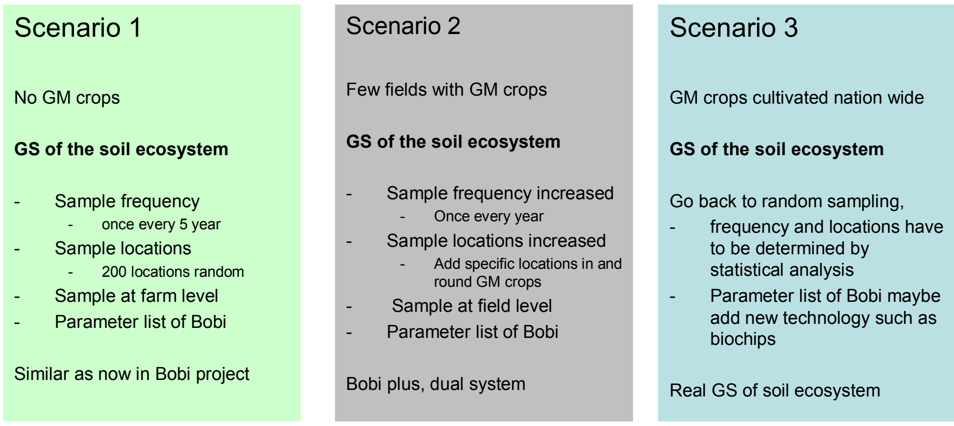

Figure 4. Schematic representation of the three scenario's for devising a General Surveillance system for the soil ecosystem depending on the amount of GM crops cultivated in the future in the Netherlands.

Scenario 1: there are no GM crops commercially cultivated in the Netherlands. This situation provides the opportunity to collect baseline data. In that case it will not be necessary to increase sampling frequencies or increase numbers of locations to the strategy now used in BISQ. It may be decided to add a number of locations in nature areas since the focus of BISQ is mainly towards agriculture. The data that are generated can be used to develop a baseline for GS, providing that the set of indicators for GS and BISQ are overlapping.

Scenario 2: there are only a few fields with GM crops commercially cultivated in the Netherlands. Then the number of sample locations is increased by selecting locations within and outside the fields with GM crops. These locations are sampled once every year. All other locations of BISQ are sampled as usual. Data from the GM fields are now analyzed on a field scale and not on farm scale.

Scenario 3: GM crops are cultivated in large parts of the Netherlands. Now a random sampling design will have to be developed. Selecting locations and determining frequency will depend on a statistical analysis. Also in the future new technological developments such the application of biochips may be included in the parameters that are measured. This will be the actual GS system.

Conclusion 5: For the design of a sampling strategy three different scenarios are described depending on the area size of GM crops.

2.4 How should the data be interpreted?

Interpretation of the data is a difficult subject. The organizers of the workshop pressed the participants to make statements on which effects would be acceptable and which effects would be worrying or harmful for soil quality. Questions were: is a 10% or 50% reduction of soil quality acceptable? The participants were reluctant to make such statements. Scientists can only determine if an effect is statistically significant or not. Statistical significance however, should not be the only criterion; ecological significance should also be taken into account. It was stated by the participants that scientists should not make judgments whether effects are unwanted. For further explanation, the participants outlined examples that occur in normal agricultural practice. For instance plowing can reduce the number of earthworms with 50%. If such an effect was caused by GM crops it would probably be considered a large effect. Since plowing is part of normal agricultural practice for a long history of time its effects are considered to fall within normal variability. Change in land use, crop rotation, soil disinfection may all seriously affect the soil ecosystem and have impact on soil quality. If such a level of disturbance will be caused by GM crops it may be considered as significant. It will prove to be very difficult to measure with two different yardsticks. GM crops are regulated but may have much smaller effects on the soil ecosystem than many accepted practices in agriculture. This may be solved to ask stakeholder to assess the effects. The participants were of the opinion that the involvement of scientists should be carefully defined; they may be involved in the design of sampling strategies and in determining the normal fluctuations of parameters that will be measured. In the proposed participation model three different groups of experts may be recognized: 1) stakeholders representing the land users that define the protection goals, 2) scientists involved in the sampling, analysis and assessment of the data who have an advisory role, 3) decision makers who will ultimately make a judgment on impacts of GM crops that exceed normal variability (see Figure 5).
The discussion then focused on the composition of the stakeholder group. In this group any representative of the society may be a member, however these stakeholders should have knowledge about the soil ecosystem to be able to understand the relevance of the data. Stakeholders may be farmers, authorities involved in nature preservation, soil scientists, ecologists and local authorities.

For a conscientious assessment of the recorded effects of GM crops it is important to compare them to the data that already exist. The effects should be compared to effects caused by normal agricultural practice of normal variability in nature, e.g. the baseline. To organise this efficiently there is need to set up a centralised body. It was decided that sampling, data collection, statistical analysis and drafting an ecological assessment is the task of experts that are part of a Central Reporting Office. Such a national focal point or reporting office is essential for managing GS, to collect data and take care of all organisational issues. A Central Reporting Office should have the task to maintain all data preferably in a GIS based system and could be part of the GMO-office at RIVM-SEC. Soil experts should provide advice about ecological relevance of the data. The interpretation of the GS data should be done by a separate entity of stakeholders or scientifically trained experts.

Conclusion 6: The GS data should be collected and stored in a database managed by a Central Reporting Office. Impacts exceeding normal variability of the soil ecosystem should be judged in relation to land usage by a board of stakeholders.

2.5 Conclusions of the first part of the workshop

1. Monitoring the soil ecosystem should be part of General Surveillance of the Netherlands and should be designed to detect unexpected effects (not 'harmful' effects).
2. It is necessary to define protection goals if one wants to set up a monitoring (GS) program for the soil ecosystem.
3. The major protection goal should be protection of soil quality.
4. To link the overarching protection goal to ecosystem services and the parameters for monitoring, a stakeholder participation model is suggested that includes various stakeholders and networks.
5. For the design of a sampling strategy three different scenarios are described depending on the number of areas or the size of GM crops cultivation sites of GM crops.
6. The GS data should be collected and stored in a database managed by a Central Reporting Office. Impacts exceeding normal variability of the soil ecosystem should be judged in relation to land usage by a board of stakeholders.

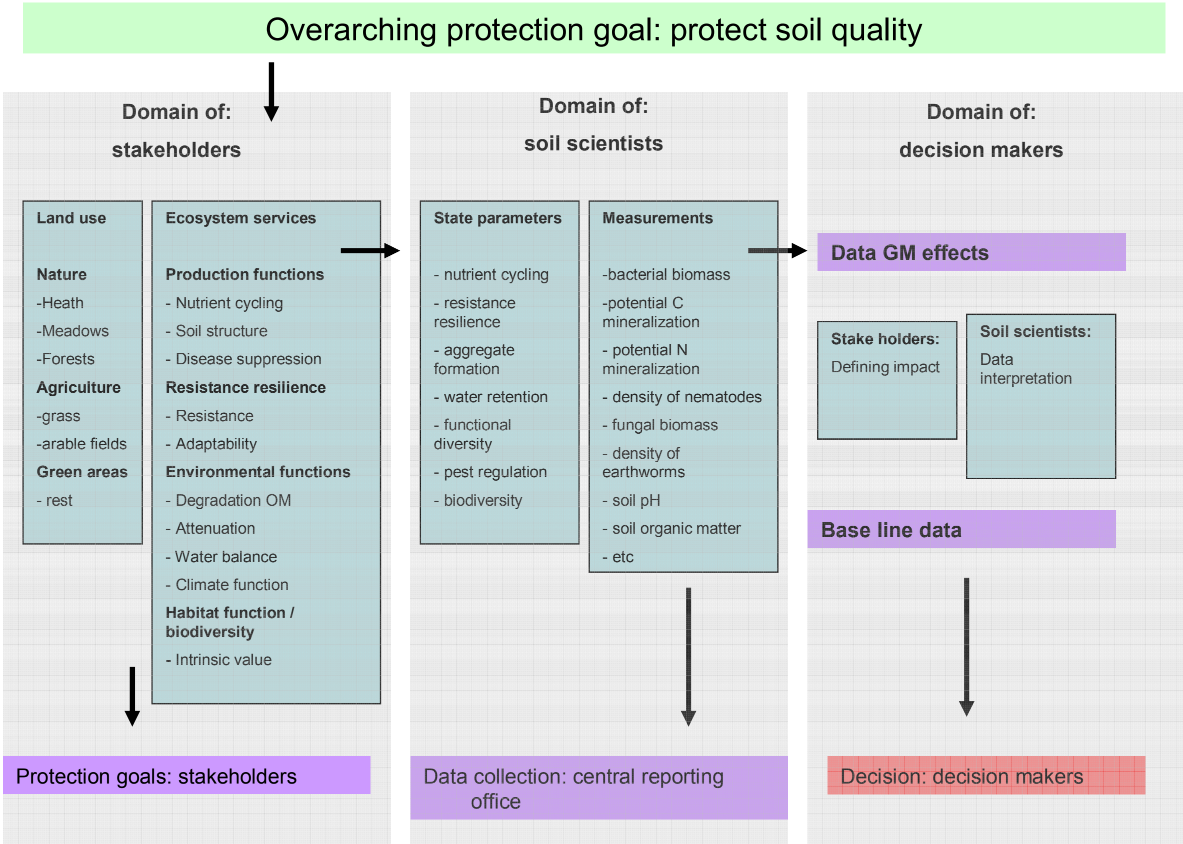

Figure 5. Schematic representation of the methodology for the stakeholder participation model for GS of the soil ecosystem (see also conclusions).

3 Discussion regarding alternative approaches for GS

3.1 Are there other approaches for GS of the soil ecosystem?

The discussion was introduced by a presentation by Boet Glandorf on indirect approaches for general surveillance of the soil ecosystem. These approaches are based on the assumption that healthy plant growth is a good indicator for soil quality. If soil quality is reduced this will become visible in reduced plant yield or increased plant diseases. First she explained what is monitored by the Dutch Network for Ecological Monitoring (NEM) and then she mentioned some basic ideas about possible application of earth observation technology and GIS systems. The participants considered the use of data from NEM and of earth observation (EOS) interesting approaches. They could not think of any other additional approaches for GS, except for the use of bioindicators for disease suppressiveness that are being developed. This may be interesting for future monitoring besides the already mentioned biochips.

3.2 Are these approaches useful for GS

The participants agreed that such indirect approaches (NEM, EOS) could be very useful, but they also stated that they cannot replace soil monitoring. Some questions were raised about the organisation of the NEM and about the species that are monitored. Monitoring the vegetation was seen as a useful complementary approach. Also insects were mentioned as an interesting group. Insects as whole are not part of the NEM, but for instance butterflies are monitored. Similarly most participants agreed that satellite images could provide additional useful information, although they were reluctant to rely on such data solely. Some participants wondered what one could actually detect using these images. Since none of the workshop participants had extensive knowledge of the ins and outs of earth observation this issue could not be discussed in depth. Currently a project is being performed to investigate the possibilities of using earth observation for GS. A combination of ‘rough’ data with the ability to zoom in/focus once something unexpected was detected was regarded as a great strength.

Conclusion 7: A GS system may include data from the NEM and from EOS such as satellite data.

All participants agreed on the fact that soil sampling can only be done on a very limited scale because of the amount of effort and budget needed to obtain the required data. The approaches outlined above have the possibility to produce incredible amounts of data with relatively limited efforts. It will probably be a huge task to link all these different approaches in one system. Therefore it was suggested not to put much effort in such an integrated approach but to use the data in separate GIS based applications. Data from the NEM and satellite images will contribute to creating an overall picture of the Netherlands when present in a GIS based data base. This will give a lot of power to the GS system. It may also be possible to include the information from the farmer questionnaires. Also other data may be valuable for GS. One may think of for instance reports from organisations responsible for nature conservation or data form BLGG (http://www.blgg.nl/blgg/molecularlabframeset.html) , a Dutch company that analyses the soil of most farmers to give them advice e.g. on the type and amount of fertilizer to be used, could provide valuable information. The Central Reporting Office should be the linking pin that collects all data and manages the GIS database (see Figure 6). This data base should also

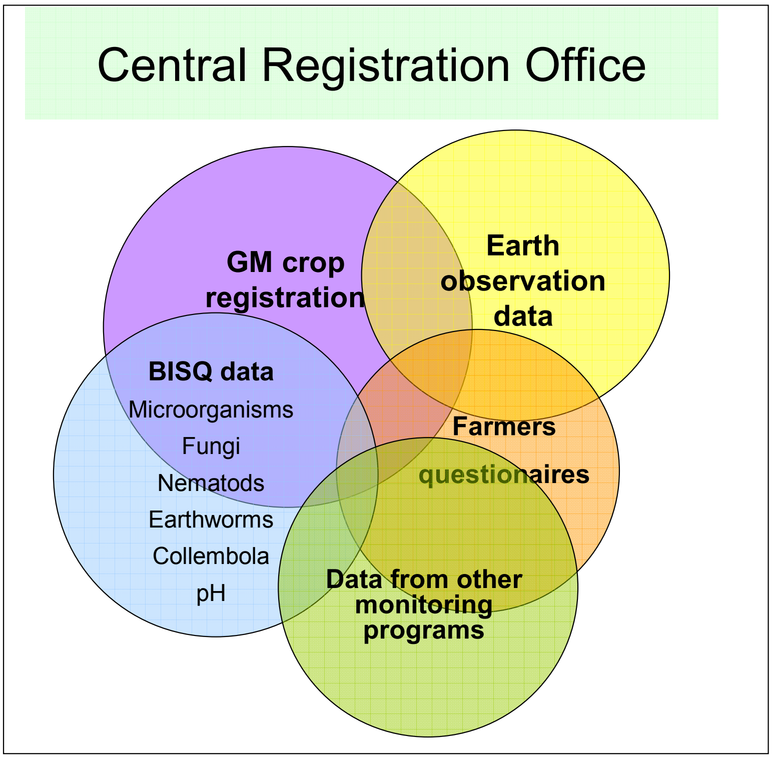

Figure 6. Schematic representation of the role of the Central Reporting Office to collect and manage data in a GIS based data base that enables us to connect or link possible unexpected effects to various sources.

include the locations of the GM crops. If the government wants to set up GS it is essential to have a Central Reporting Office that is responsible for data maintenance and communication.

Conclusion 8: Data from soil measurements (BISQ), earth observation, GM crop registration and possibly farmer questionnaires should be compiled by a Central Reporting Office in a GIS based data base.

This Central Reporting Office should also check the quality of the data before it is entered into the data base and the office should also be able to ask soil experts to provide advice on ecological relevance of potential effects on the ecosystem.

Regarding the quality of the data and the statistical power it is essential to test the GS system beforehand by for instance assuming a soil quality reduction of 50% and to check of the proposed GS system could pick up such an effect. The participants agreed that a thorough statistical analysis should be performed to predict the sensitivity and discriminating power of the proposed GS system

Conclusion 9: The power and resolution of the proposed soil monitoring strategy for GS should be analyzed statistically.

Depending on their impact, detecting effects will prove to be difficult. In a short presentation Olivier Sanvido outlined the experience of Switzerland with their monitoring program. In Switzerland GS is a continuation of surveillance programs that were already in place. A study was done on the sensitivity to detect changes in butterflies. The results were very frustrating: only with a very intensive sampling strategy a decrease of 50% could be detected in a statistically sound way, due to the high natural variation. It can be concluded that small effects will never be detected. Then the starting question was raised again: is it useful to set up a GS system when it will only be able to detect very large effects? Nevertheless, all participants were convinced of the necessity to implement a GS system. It was argued that it is a governmental task to protect the environment and there should a mechanism to detect large, discernable and measurable effects of GM crops. Moreover a decision to set up GS is not purely scientific, but it’s a political and social issue as well.

3.3 Conclusions regarding alternative approaches for GS

- A GS system may include data from the NEM and earth observation systems as well a other data resources (e.g. farm questionnaires or reports form organisations involved in nature conservation)
- Data from soil measurements (BISQ), earth observation, GM crop registration and possibly farmer questionnaires should be compiled by a Central Reporting Office in GIS based data bases
- The power and resolution of the proposed soil monitoring system should be statistically analyzed

4 Concluding remarks

According to European legislation each EU country should have a General Surveillance system designed to detect unexpected effects of genetically modified crops on the environment. Monitoring of the soil ecosystem should be part of a General Surveillance system in the Netherlands. GS should be designed to detect unexpected effects. For the development of a GS system it is necessary to define protection goals for the soil ecosystem. The overarching protection goal should be protection of soil quality. To link the overarching protection goal to ecosystem services and the parameters for monitoring, a stakeholder participation model should be set up that includes various stakeholders and networks.

For the design of a sampling strategy three different scenarios are described depending on the number of areas or the size of GM crops cultivation sites of GM crops. The power and resolution of the proposed soil monitoring system should be statistically analyzed. The GS data should be collected and stored in a database managed by a Central Reporting Office. Impacts exceeding normal variability of the soil ecosystem should be judged in relation to land usage by a board of stakeholders.

A GS system may include data from the NEM and earth observation systems as well as other data resources (e.g. farm questionnaires or reports form organisations involved in nature conservation). Data from soil measurements (BISQ), earth observation, GM crop registration and possibly farmer questionnaires should be compiled by a Central Reporting Office in GIS based data base.

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Abbreviations

GS	General Surveillance
GM	Genetically Modified
GMO	Genetically Modified Organisms
BISQ	Biological Indicator for Soil Quality program
Bobi	Bodembiologische indicator
C	Carbon
N	Nitrogen
NEM	Netwerk Ecologische Monitoring
GIS	Geografisch Informatie Systeem
EOS	Earth Observation System

Annex 1

Consultation of Dutch soil experts regarding the development of a General Surveillance system for the soil ecosystem

Part of the preparation for this workshop was to interview 8 Dutch soil experts. In this annex the questions and a summary of the answers is provided. The number indicates the number of times that this specific answer was given by the experts.

Give your definition of harmful effects on the soil ecosystem

1.	loss or disruption of essential soil functions	4
2.	loss of biodiversity or species	2
3.	accumulation of toxic compounds in the food chain	2
4.	deviations falling outside the Normal Operating Range	1
5.	that is a political or societal issue not a scientific one	1
6.	irreversible effects	1

What is the most important soil function that should not be disrupted

1.	nutrient cycling	3
2.	ecosystem services	2
3.	soil productivity (agronomic)	2
4.	biodiversity	2
5.	suppression of plant diseases	2
6.	degradation of environmental unknown compounds	1
7.	loss of soil structure	1
8.	key species such as mycorrhiza and N fixing bacteria	1

How we can determine the scale of fluctuations of these functions

1.	long term observations of different soil types are important to assess the variations in populations and functions	2

2. monitor economic consequences 2
3. large fluctuations may occur, one should attempt to reduce these fluctuations using proper sampling protocols and methods 1
4. monitor biodiversity including fungi 1
5. determine the NOR 1
6. determine extremes of certain soil types and do long term observations 1
7. long term measurements and check if values are outside 95% range 1
8. monitor for changes in characteristics of ecosystem 1
9. determine nutrient cycling in long term 1

How we could monitor these soil functions

1. Bobi including a custom made assessment system 3
   However most experts express their concerns regarding establishing a correlation between GM crops and the data
2. molecular methods 2
3. chips with sequences from soil organisms 2
4. monitor mycorrhiza 2
5. determine plant biodiversity 1
6. traditional and molecular methods and specific functional genes 1
7. monitor disease suppression 1
8. a monitoring system is often based on the wrong parameters, direct measurements are more informative 1

Which methods are suitable to apply routinely on a large scale and cost effective

1. Bobi has proven to be suitable and costs €3000 for the whole set of indicators per location per year (one indicator costs €200) 2
2. good indicators are:
   a. N mineralization 3
   b. Fungi 1
   c. Earthworms 2
   d. Soil structure 1
   e. Biodiversity 3
   f. Organic matter 2

g.	Functional genes	3
h.	Nutrient leaching	1
i.	Nitrification	1
j.	Soil respiration	3
k.	Nematodes	1

3. in the future microarray based methods might be useful 3
4. quantitative PCR for specific functional genes 2
5. monitoring biodiversity of plants, fungi and mycorrhiza 1

Which indicators could be suitable to monitor abovementioned functions

1. indicators used to determine ecological services 2
2. important indicators are:
    a. organic matter content or degradation rate 3
    b. biodiversity and functional diversity of bacteria 2
    c. fungi 1
    d. diversity and species richness of nematodes, 2
    e. mycorrhiza 2
    f. earthworms 2
    g. N fixing bacteria 1
    h. Nitrification 1
    i. the above in a combination of general parameters such as fatty acid analysis and DGGE 1

Which monitoring programs or other initiatives in the Netherlands to which a GS system may connect to do you know

1. Bobi and LMB 4
2. ERGO program 1
3. provincial monitoring programs 1
4. Bllg's measurements 1

Explanation of abreviations:

Bobi = program for the development of a biological indicator system for soil quality

LMB =Netherlands soil monitoring program

ERGO = Dutch research program stimulating GMO environmental risk assessment research
Bllg = Dutch soil research and advise company for farmers

How can we analyze and interpret the data and how can we choose the right references and controls

1. References or controls do not exist (3), you might use the NOR as reference (1) or a GMO free location (2).
2. Interpretation of the data will be very difficult since real controls do not exist (2), this can only be done by expert judgment (1).
3. Determine references using a multicriteria process by interviewing a panel of soil users and use the data from these locations to compare to the other locations (1).
4. Suitable references could be natural grassland or biological farms (1).
5. for data interpretation you might use the system developed in a SKB project ‘Analyse Nematode Bestand’ (IWACO) (1).
6. To establish a baseline it is important to determine the baseline in a long term approach (LMB) (1).

What would be the optimal sample frequency and what would be the optimal geographical distribution of the sample locations

1. sampling at least all different soil types present in the Netherlands twice a year
2. 500 locations sampling once every 5 years
3. sampling different soil types clay, peat and sand, at least once per 5 years
4. use the systematic devised for he LMB, e.g 200 locations in the Netherlands that are sampled once every five years

Are there methods being developed that may of value for a GS system in the future

1. follow the ERGO program 1
2. molecular based method to monitor decomposers, N fixers and mycorrhiza 1
3. remote sensing 1
4. a public phone number to report unusual effects 1
5. Pyrosequencing to get an overview of the most abundant sequences (species) in the Netherlands, 1
   or:

a. phylochips or soil chip (3)
b. quantitative PCR on functional genes (2)

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