Review of the Long-term Experiments at the Faculty of Natural Resources and Agricultural Sciences

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by

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and

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1. Introduction

We begin by thanking the Faculty of Natural Resources and Agricultural Sciences for inviting us to make this review. SLU is clearly an outstanding university delivering excellent science of practical relevance to farmers and advisers and we have been delighted to assist it, and the Faculty in particular, through our review.

We thank Professor Barbara Ekbom for coordinating the review and for her support during the review. We also thank her colleague, Lena Ekeroth, for providing administrative support, and all the scientists that we met during the week for their helpful participation in preparing material beforehand, presenting their experiments to us and answering all of our questions.

2. Basis of the review

We were given a positive brief: to review at the resources available in the Long-Term Experiments (LTEs) and to propose ways to maximise their usefulness and relevance to Swedish agriculture and likely future science.

We would like to begin by saying that we regard LTEs as an invaluable resource for research, extension and teaching. Their value goes far beyond the often simple scientific questions that they were designed to answer and, when carefully managed, are a resource that increases in value and has a relevance far beyond anything that was envisaged by those who initiated them.

We have often used examples from our own LTEs at Kellogg Biological Station and Rothamsted when explaining our ideas or suggestions. That is not because we regard these as exemplars but because we are most familiar with them. The increasing awareness of the value of LTEs has

resulted in a number of websites and databases that list them, with different degrees of detail. One of these is the website at Duke University in the US, created by Professor Dan Richter. We have already introduced some of the research staff at SLU to this website and would encourage participation in it and similar sites where relevant, to maximise the visibility of the experiments.

3. Long-term experiments reviewed (the figure in parenthesis is the support to each group of experiments provided by the Faculty in 2006)

The details of the various long-term experiments managed by the Faculty, as sent to us by the Divisions, are appended. Here we merely give a simple list:

3. 1. Department of Soil Sciences (5,000,000 SEK)

3.1.1 Division of Soil Management, (898,000 SEK)

R2-4007, Tillage systems – need for soil loosening
R2-4008, Different tillage systems – different intensities
R2-4009, Different tillage systems – placement of fertiliser.
R2-4010, Different tillage systems – straw management
R2-4014, Subsiding of peat soil
R2-4017, Direct drilling
R2-4027, Tillage depth in ploughless tillage
R2-4111, Time of primary tillage in the autumn – effect on crop yield, soil structure and nitrogen mineralization
R2-7115, Low tyre inflation pressures in tillage systems with and without ploughing
R2-8407, Nitrogen efficient tillage systems

3.1.2 Division of Hydrotechnics (350,000 SEK)

R1-138 Subsidence of peat soils and the effect of copper fertilization
R1-143 & 143M The long term effect of liming on soil structure

3.1.3 Division of Water Quality Management (1,552,874 SEK)

Long-term experimental sites for studying nutrient losses, nutrient turnover and model developments at:

1. Hedemora. Phosphorus, nitrogen and erosion via surface runoff from this silty soil have been monitored in different tillage systems.

2. Wiad is situated on a silty clay loam in Central Sweden. Factors such as application of solid manure and production of perennial ley have been studied.

3. *Bornsjön.* This is a new site specially designed to study phosphorus losses to the Baltic Sea from a marine clay soil.

4. *Lanna*. This clay soil carries long-term experiments focusing on phosphorus and nitrogen losses to drainage waters from both conventional and organic systems.
5. *Fotegården.* The studies on this sandy soil form an important complement to the findings from the Mellby site.
6. *Mellby*. Leaching studies from this sandy soil at Laholm Bay, which is exposed to high precipitation, started in 1984. The studies have focused on the impact of catch crops and slurry incorporation on nutrient leaching in both conventional and organic farming systems.
7. *Böslid.* This is a more loamy sand than at Mellby and without iron mottles in the soil profile.
8. *Lönnstorp.* This soil is a loamy soil in the most southern part of Sweden and experiments are focused on more locally important crops, e.g. sugar beet.

3.1.4 Division of Plant Nutrition and Soil Fertility (2,228,000 SEK)

R3-0020 and R3-0021 Humus balance in cereal cropping systems and in clover/grass production systems.
R3-0056 Cropping systems and environmental effects.
R3-0130 Soil biological experiment.
R3-1001 Lime and phosphorus (containing the oldest LTE in Sweden, begun in 1936)
R3-1002 Lime and organic matter.
R3-1037 Lime and soil chemical properties.
R3-2037 Soil fertility experiments. North Sweden.
R3-3038 Exploiting P in heavily dressed soils.
R3-9001 Soil fertility experiments. Central and south Sweden.
Frame56 Organic matter experiment; Started 57.

3.2. Department of Crop Production Ecology (1,180,000 SEK)

3.2.1 Division of cropping systems (925,000 SEK)

R4-0002, Project 01. Crop sequences with different cropping strategies
R6-906-2, Project 02. Trials with monocropped spring cereal.
Project 11. Crop rotations with or without ley.

3.2.2 Division of Weed Science (200,000 SEK)

1. Minimizing use of herbicides.
2. Long term effects of herbicide use.
3. Weed control in grazing land, influence on flora and fauna.
4. Influence of problem species in grazing land.
5. The influence of management methods on flora and fauna in grazing land.

3.3. Department of Entomology (245,000 SEK)

3.3.1 Division of Landscape Ecology (20,000 SEK)

Long-term studies of establishment and management of vegetation in broadened field boundaries (three trials).

3.3.2 Division of Entomology (225,000 SEK)

Long-term population dynamics of a perennial herb and its insect herbivores (two trials)

3.4. Department of Agricultural Research for Northern Sweden (400,000 SEK)

R8-71B, Long term experiment with different crop rotations (one site).
R8-74, Long term experiment with monoculture (three sites).

4. General comments

We regard the LTEs managed by the Faculty as an invaluable resource to the Faculty, to Swedish agricultural research and its farmers and wider farming community, but also to the international research community in general. The vision of those who established the experiments is to be commended for their far-sightedness, and those who have maintained and managed them for their carefulness. Long-term experiments have, of course an initial relevance in the context of the question or hypothesis posed, but a wider relevance as (i) platform sites for research probably not envisaged when the experiments began (e.g. the measurement of dioxins, PCBs and furans in archived soil samples at Rothamsted); (ii) a teaching resource for undergraduate and graduate students; (iii) demonstration plots for farmers, advisers and the general public; (iv) opportunities to test basic ecological and biogeochemical questions that can not be addressed without long-term information series and resource response to perturbation.

The LTEs that we have reviewed mostly have plot replication and site replication. This is invaluable. The very old LTEs, such as those at Rothamsted, have no replication and it is now recognised that plot replication alone is not enough for the wider application of results from LTEs across soil types, climates and landscapes.

We noted that the LTEs were mostly sited away from the main SLU campus at Ultuna and so were necessarily managed by local SLU campuses or farmer groups. However, these staff are well-trained and we have few concerns about the management of the LTEs.

We commend the Faculty for continuing to support the LTEs through a time of financial difficulty. We hope that it will continue to provide such support, adjusted at least for any inflationary increases in costs and, where appropriate, providing additional support where science and relevance justify this. We are aware that the Divisions would like more funding (who would

not!) and that they have lost research staff. We have tried to be realistic about likely future funding in our recommendations. We note the Faculty's reward scheme in which c 70,000,000 SEK are distributed according to the number of refereed papers published and external funding secured. This may be of some help, but publications come slowly from LTEs and some are more relevant to external funders than others. We would comment that, from our experience, the level of basic funding from the Faculty is good and external funds appear to be more easily won than in many countries.

We commend the scientists we met for their enthusiasm and commitment to the LTEs. We were impressed by their depth and breath of knowledge and their desire to see the experiments continue and to be more widely valued by their fellow scientists. We were also impressed by the amount of external funding that many of the Divisions had obtained to add to the funds from the Faculty: the ratio of external to internal funding was 3:1 in some cases, and LTEs were in European Union research programmes. It should be noted, however, that external funding cannot deliver a long-term research strategy for the LTEs because funders needs are short-term and change rapidly.

We also note the often conflicting pressure to publish reports and practical information in Swedish and peer-reviewed papers in English. Staff should be given credit for appropriate publication, directed by funding and job description.

We note that the research staff associated with the LTEs are under similar pressures to all scientists to make their data freely available. The implications of such a policy are being widely discussed because of the possibility that the instigator and owner of an experiment would find that someone else had obtained the data and published ahead of them. The Faculty, and SLU generally, should be aware of this in any discussions of access to data.

We have made an attempt to summarize some information about the LTEs, including the scale of operation and types of research being conducted from basic to applied. This is presented in Table 1. The table is not a comprehensive overview but rather a 'thought piece' to stimulate discussion of the objectives for the trials, within different disciplinary contexts. There is value to be gained, we suggest, from considering the specific strengths associated with different trials. Many have value as a unique resource for addressing basic research questions, particularly the oldest trials which provide a platform for addressing the effect of climate change or new equilibrium states of management and effects on soil and plant diversity. Other trials might consider the valuable of explicitly linking trials to applied systems questions. In Michigan, the Long-term Ecological Research Row crop trial is in the process of being 'scaled up', which involves linking trial monitoring to the monitoring of managed landscapes (specific farm systems, or a mosaic of farm, forest, successional systems and grassland) to evaluate spatial heterogeneity and agricultural systems questions such as farmer adoption, profitability and risk assessment as well as predicting environmental consequences. Farm advisory groups to help manage systems experiments, such as is done with the Rodale long-term organic vs conventional Farming Systems Trial in the USA, is another example of systematic linking a trial to stakeholders to enhance relevance and the rigor

of the applied science. The water quality group at SLU provides an example of addressing basic, applied and watershed scale questions, including long-term trials and environmental monitoring. Other models of linking long-term trials to basic or applied research objectives might be considered by the researchers involved in the LTEs at SLU.

5. General Recommendations

5.1 We recommend that the Faculty consider a long-term management strategy for all of its LTEs, including a Management Board comprising representatives of each Division that manages some of the experiments, but also the user community such as prominent farmers and policy makers. A Management Board such as that described above would facilitate this. We understand the Faculty of Forest Sciences has its own series of LTEs. We would encourage the faculties to consider a joint management board for the LTEs so that SLU LTE resources are consistently supported and managed. Concern was expressed by some of the staff we met that the LTEs were not adequately integrated into the Faculty's research programme, so thought should be give to whom else has a logical stake in these long-term trials from both inside and outside of SLU, and could be invited as representatives on this Management Board. For example, a case might be made for including a social scientist, an environmental policy maker or consumer and community nutrition scientist.

5.2 We recommend that the Faculty urgently consider its succession planning for the LTEs. Some of the Divisions have younger scientist involved with the experiments but some not, with essential knowledge and skills residing in perhaps one person. Rothamsted recently undertook a risk analysis of its research and identified the manager of its LTEs as the most risk-critical member of staff. Resources were subsequently allocated to enable a successor to be appointed and trained.

5.3 There are many LTEs around the world. These are listed, with different degrees of detail, on some websites such as that run by Professor Dan Richter at Duke University in the US: http://ltse.nicholas.duke.edu/
We recommend that the Faculty's LTEs are registered on this website to increase awareness of them by the wider scientific community.

5.4 There is also an increasing number of long-term environmental research and monitoring sites, such as the US Long-Term Ecological Research (LTER) sites and the UK's Environmental Change Network (ECN). Rothamsted gains great value in having its LTEs as part of the ECN. We recommend that the Faculty consider how its LTEs might become part of such a network in Sweden or at least be linked to these.

5.5 We understand that staff working on LTEs are expected to supply data and information, and also provide experimental sites for student projects and researchers, at no cost. There is a cost in providing such support, and so we recommend that the Faculty consider making a charge for such use of staff time and nominal experimental costs.

5.6 There appear to be at least two databases on which data from the LTEs is archived and two archives in which samples are stored. We recommend that the Faculty discuss with the Faculty of Forest Sciences the construction of a single database for all of SLU's LTEs and

that the discussion includes the problem of access: by whom, for what and with what controls or limits. The question of possible integration of forested and natural LTE sites with the agriculturally managed LTEs could be considered, where long-term observations have been undertaken adjacent to the LTEs or where forested sites are coincidentally available for use as reference sites near an LTE.

5.7 Our one criticism of most of the scientists managing and using the LTEs was that their vision for the future was generally limited to their own discipline, perhaps summed up by the phrase 'more of the same'. We encourage (rather than recommend) the scientists to look beyond their discipline and see how the LTEs could be used, for example, in answering some of the environmental, ecological and socioeconomic questions that are relevant to sustainable agriculture. Wider use of the LTEs might require some changes to management, or microplot experiments within the main plots, but this should be considered. Changes to the Rothamsted LTEs have been made, and microplots used, after careful consideration and with great benefit.

5.8 In this context, we encourage the development of multidisciplinary activities on some of the LTEs. We are aware that multidisciplinary science has specific challenges including the time required to build quality relationships across disciplines with different vocabulary and scales or norms of operation for carrying out research. There is a building consensus in the scientific community that cutting edge, applied science needs to take into account the biocomplexity of real world systems, and thus encourage the development of multidisciplinary research. Long-term trials are unique platforms for multidisciplinary studies of systems which have reached equilibrium and are associated with longitudinal information on response of resources such as soil, plants and water to management and perturbation.

5.9 Interaction with other disciplines and in particular with ecologists, modelers and statisticians may provide extra value to long-term trial researchers. These trials are systems, and those with expertise in system science could be usefully drawn into the research planning, implementation and analysis process. We recommend that the Faculty organise a meeting focused on LTE research approaches might increase understanding of the tremendous resource at SLU to the national and international scientist audience, provide unique insights and directions of inquiry for SLU researchers, and build new collaborative projects.

5.10 We understand that there will be a conference to celebrate 50 years of R3-9001 and Frame56. Opportunity should be taken at this conference to at least publicise the full range of LTEs at SLU and, preferably, to have at least one presentation that features the full breath of LTEs available. We hope that the conference will be publicised as widely as possible on an international stage

6 Specific comments and recommendations

6.1. Department of Soil Sciences

6.1.1 Division of Soil Management

We thank Thomas Rydberg and colleagues for the tour of some of the LTEs near to Ultuna. We commend this group for their extensive collaborations with other research groups, success at

winning external funding, for producing a commendable number of research papers while also meeting farmers' demands for practical advice, for accepting the need for occasional change to the LTEs to maintain relevance, and for their future plans and confidence in long-continued relevance of the LTEs and ability to raise external funding. We agree that these LTEs are very relevant to the EU Soil Framework Directive.

6.1.1.1 We were especially impressed by the efforts of Prof Rydberg and colleagues to obtain funding for a proposed Centre for Longitudinal Investigations, which would have focused of the LTEs. We recommend that he and all those who prepared the proposal consider how the bid might be revised and resubmitted to appropriate funders. The proposed Management Board could play a key role in this.

6.1.1.2 We are aware of plans to construct new tile-drained plot experiment in the south-east of Sweden. We agree with Prof Rydberg that consideration should be given to constructing a similar experiment on clay soils in the west of Sweden.

6.1.2 Division of Hydrotechnics

The research being conducted with R1-138 is clearly relevant to climate change, carbon sequestration and the sustainable management of organic soils, and R1-143 and 143M address the considerable concern in Sweden about soil structure and the possibility that compaction has occurred over the long-term. The group has been involved in interdisciplinary research on its LTEs with, e.g. crop ecologists. We commend the staff for their leverage of external funding, which includes EU (Europeat). All of these LTEs appear to be on farms and so are at the mercy of the farmer.

6.1.2.1 The improved peatland could lose large quantities of N if abandoned and allowed to wet up. We recommend that some resource be allocated to adapting some of the R1-138 to monitoring the risk of this and modelling likely greenhouse gas emissions.

6.1.3 Division of Water Quality Management

We commend the group on the comprehensive papers presented to us, on their success in winning external funding, and on their publication rate. It was impressive to see the integration of research with applied outcomes, farmer adoption and environmentally significant ones at that. The LTEs have delivered excellent science and are of practical relevance; the research is clearly valued by farmers. Members of the group interact with policy makers. The group had lots of ideas for using the LTEs but, despite their success at winning external funds, felt limited by lack of resources. We also commend them for their collaborations and interactions both nationally and international, e.g. in the Food21 programme. We are pleased to hear that they would like to be associated with other LTE networks but are limited by resources.

6.1.1.1 We recommend that the group explore the use of physical fractionation methods for its carbon and nitrogen cycling research and advice on SOM management to farmers.

6.1.1.2 We recommend that the group explore collaborations with soil microbiologists using molecular techniques to open up new areas of research in nutrient cycling.

6.1.1.3 We also recommend that collaborations with the Cropping Systems and Soil Management Groups be considered to expand the multidisciplinary nature of the research undertaken and widen relevance.

6.1.4 Division of Plant Nutrition and Soil Fertility

The LTEs managed by this division include the oldest in Sweden, begun in 1936. We commend Lennart Mattson for his diligence in maintaining the sample archive and database, for putting much effort into transferring written data into electronic format, and for the comprehensive review of experiments 2037 and 9001. We note Dr Mattson's concern that there are too many experiments to be managed with the resources available and his view that two of the phosphorus trials could be stopped.

6.1.4.1 We recommend that the proposed Management Board instigate a review of all the LTEs in the context of the proposals to end some and begin new LTEs. For example, a wide range of expertise on phosphorus biogeochemical cycling from different disciplines at SLU could provide new perspectives on research possibilities for LTEs, both basic and applied in scope. We also recommend that, rather than ending experiments and returning land to normal production, that consideration given to taking some experiments out of active management and grassing them over ('mothballing') so that the plots remain intact and available for future sampling and use. We have adopted this practice with several LTEs at Rothamsted. A multidisciplinary review could provide diverse viewpoints and identify unique value and research opportunities within some trials initially set up with objectives that may not appear relevant today.

6.1.4.2 We also recommend that the Faculty give urgent attention to finding a successor to Dr Mattson to ensure that expertise is not lost. If possible, this needs to someone young and committed to the LTEs so that their management is ensured for several decades.

6.1.4.3 We understand that some water samples have been collected but not analysed because of lack of resources. In view of the importance of monitoring losses of fertilisers in drainage waters, we recommend that these samples be analysed as soon as possible.

6.1.4.4 In view of the common interests in drainage waters between this Division and Water Quality Management, we recommend closer collaboration between these Divisions for management of their LTEs.

6.1.4.5 In view of the success of other Divisions in attracting external funding for their LTEs we recommend that some effort be made to consider how the LTEs in this Division might be used in externally funded research.

6.2. Department of Crop Production Ecology

6.2.1 Division of cropping systems

Göran Bergkvist became responsible for thee LTEs in 2004. We commend him for putting all the data from these onto the SLU database. We note that the number of LTEs has been reduced to 7 and that Dr Bergkvist would like to close two more (R4-0007 and O4-0007).

We commend the wish to use the LTEs for work on climate change, especially modelling the impacts of climate change on crop rotations. We also commend the eagerness to publish the work to date and to collaborate with other research groups, notably Soil Management, Water Quality Management and Weeds. We are especially pleased with the planned collaborations with

Professor Jansson of the Microbiology Department and note her support for the LTEs. We also commend the desire to seek external funding. The planned approach, via the Cropping Systems Group, seems very sensible, and the desire to collaborate with modelling and statistical expertise is an excellent approach.

6.2.1.1 We recommend that the possibility of modifying an existing LTE to meet the needs of the new work be considered carefully before a new LTE s begun. Collaboration with other divisions may reveal other long-term trials where crop rotation involvement could be incorporated and perhaps address the new objectives being considered for future long-term trials, building on existing trials. If R4-0007 and O4-0007 are ended, we recommend that these be 'mothballed' i.e. sown to grass to preserve the plots rather than put back into normal agricultural production. This will preserve the soil resource for innovations in molecular and other techniques in the future.

6.2.1.2 We recommend that the planned collaboration with Professor Jansson, to study microbial functional ecology on the LTEs be encouraged if not supported.

6.2.2 Division of Weed Science

This set of LTEs contains two of the oldest, begun in 1954. We note with approval Dr Fogelfors view that weed science can no longer be as 'applied' as it was but must have a basic science focus. This change of emphasis has enabled the group to maintain a staff of 8-10 at a time of declining funding, especially from the chemical industry, which funded many herbicide trials throughout the 1980s but not now. We commend the Division for its use of the LTEs for teaching – students, policymakers and the public. The group has produced some good publications, especially in recent years. The current focus, on aggressive weeds and reduced herbicide use is appropriate and we support the proposals for future research that will study the benefits of crop rotations for reduced herbicide use, and the impacts of climate change and floral diversity on weed control. We note that Faculty funding will be essential for this work to proceed. We also endorse the view that the research must focus on scientific principles and serve both organic and conventional farming. The separation of the systems by the funders is not scientific and is based more on beliefs and politics.

6.2.2.1 We were very interested to learn about the 20-year old farm systems study on organic and conventional farming. We appreciate the problems of running such a study but believe that system studies such as this are essential for answering the complex, multidisciplinary science questions that need to be posed. We recommend that this study be included in any future review of the LTEs, with suitable background material.

6.3. Department of Entomology

6.3.1 Division of Landscape Ecology

This is a very modestly funded series of LTEs, essentially a series of field margins, and we were impressed with what has been achieved with so little funding. The age of these experiments makes them of great value in assessing policies for margins and in demonstrating their usefulness. The work has been published in good peer-review journals. We were impressed by Dr Lagerlöf's collaborations with mathematicians and botanists, idea for linking margins and buffer zones, and by his use of the margins in demonstration and teaching. He has plans to use MSc and PhD students to extend the work, but this will require funding.

6.3.1.1 Succession is clearly a problem and we recommend that the Faculty ensure that this research is integrated with other appropriate research, such as the weed trials.
6.3.1.2 As we say above (section 5.5) we appreciate Dr Lagerlöf's desire to publish his work before making the data available, but we recommend that the data be put into a database at some stage.

6.3.2 Division of Entomology

The work supported in this Division is not so much an LTE as long-term monitoring. We appreciate that, because of the nature of the research, it could not be done at an LTE. We were pleased that Dr Solbreck is aware of the usefulness of having the 'experiments' listed in international databases and plans to do that when the work is published.
6.3.2.1 Succession is also a problem for Dr Solbreck. We were very impressed by Dr Solbreck's vision to ensure that his research can be continued at a stage in the future by describing in detail what he has done. We recommend that he be supported in this.
6.3.2.2 We recommend that the monitoring sites be georeferenced as this would greatly enhance their value.

6.4. Department of Agricultural Research for Northern Sweden

These LTEs clearly have regional importance. We appreciate that some LTEs had to be closed in the 1990s because of lack of funding and we commend Dr Ericson for his clear view of what should be the focus of those that remain – soil carbon, nutrient supply and microbiology. We note that funding is enough only to maintain the experiments; extra funding is needed for research, as it is for all of the LTEs.
We commend the collaboration with the Divisions of Soil Management and Plant Nutrition and Soil Fertility. We are especially pleased with the collaborations with Professor Huss-Danell of the Department of Agricultural Research for Northern Sweden and Professor Näsholm of the Department of Forest Genetics and Plant Physiology for the research into plant-available organic nitrogen. We agree with the proposal to analyse the soil from the Offer site for changes in organic carbon in the context of carbon sequestration by farmland. We were especially pleased to hear of Dr Ericson's attempts to raise the profile of the LTEs and, with Dr Fogelfors, to use them for environmental monitoring.
We were also pleased to discuss, for the first time with any of the Divisions, the role of biometrics (statistics) in the LTEs. We note the comments that the biometricians feel that they have lost contact with practical research and want to renew this link. We also note that the proposed Centre for Longitudinal Studies would facilitate this.
6.5.1 We recommend that the Faculty strongly support the use of the LTEs for environmental monitoring (see 5.3 above).
6.5.2 As we say above (6.1.1.1) we recommend that the proposal for the Centre for Longitudinal Studies be revised and resubmitted.
6.5.3 We note that the data from these LTEs are in a database at Umea. Dr Ericson would like to transfer them to the Ultuna database and we recommend that he be supported in this.

Table 1. Providing a brief overview of how trials operate at different scales, to meet a range of objectives.

Division	**Basic Processes**	**Long-term Trials**	**Environment/ Larger Scale Impact**
Water Quality	Lysimeters, Modeling N and P losses	~8 sites (large plots, reps across sites in some cases, not within sites, tile drained)	~50 farm sites monitored Interaction with policy, farmer practice and stream nutrients
HydroTech.	Lysimeters, gaseous losses	~3 trials, multiple farmer managed sites	-
Plant Nutrition and Soil Fertility	Frame expts, soil biology	Many trials ~10 and sites across Sweden, Oldest ag trials, Central archival system, samples since 60s, and for other divisions	- Farm Councils support applied short-term trials
Soil Manage-ment	-	~12 Replicated within site research station Recent est. reference grass plots	- Interaction with farmer practice; ag industry Building collaborations
Landscape Ecology	-	~3 field margin studies	-
Entomology	Long-term observations	-	-
Cropping Systems	- Building collaborations: soil biol. models Statistics	~4 rotation studies, some at multiple sites	- Building collab. with soil management, weeds, fertility and ag councils
Weed Science & Ecology	Weed pop dynamics	~4 trials, some at multiple sites + Organic/conv 20yr systems comparison	- Building collab.
Northern Sweden Ag	Organic-N direct uptake	~ 3 trials, some at multiple sites	- Building collab.