

Research and Development

Final Project Report

(Not to be used for LINK projects)

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Project title	Programme advisor for the Uplands Assessment Unit		
MAFF project code	BD1223		
Contractor organisation and location	Professor Robert H Marrs University of Liverpool		
Total MAFF project costs	£ 8750		
Project start date	01/08/99	Project end date	31/03/00

Executive summary (maximum 2 sides A4)

1. All contractors undertaking projects within the Uplands Assessment Unit were visited at least once during 1999, and the progress of all work reviewed.
2. A workshop meeting was held in London where presentations were given on most projects to an audience of MAFF and FRCA staff, as well as other invited interested parties.
3. The thematic approach developed in 1998 was continued with minor alterations, the themes being:
 - (a) Resource monitoring,
 - (b) Prediction of change in species composition at different grazing intensities,
 - (c) Measurement of Calluna performance,
 - (d) Development of weed control and vegetation restoration methodologies, and
 - (e) Information flow to users.
4. Most projects are meeting milestones and delivering outputs, two projects have caused some concern.
5. A few general areas of concern were identified, specifically:
 - (a) Links to end users - difficulties in getting good practice through to the farmer.
 - (b) Publishing work from the Program in the refereed scientific literature.
 - (c) Links with similar research in Scotland and Northern Ireland.
6. The importance of model development was emphasised. This is crucial because vegetation change and any impact on it happens so slowly in the uplands. Thus models are needed to predict at least 10 years ahead. These models must be backed up by good long-term experimental work across the country.
7. These models and experiments must be robust enough to cover future changes in policy; eg Tir Gofal and the implementation of BAP targets

8. The only real area of concern has been projects BD1203 and BD1215. For a variety of reasons they have not produced the useable model output for England and Wales. A suite of options to redress this are suggested.
9. Recommendations for existing projects are made as well as the identification of gaps in the program, where further research is needed.
10. There is a need for a better strategy for getting information across to the end user (policy-maker or farmer). The development of models will help to some extent but other avenues may be possible - for example, a forum of users and scientists tackling selected issues and developing information sheets, or by creative use of the Internet.

Form of report

The report is split into a strategic review followed by a substantial Appendix (Appendix I) which includes (1) the terms of reference, (2) description and classification of the projects within the Unit, and (3) details the visits to contractors and (4) gives an individual assessment of each project.

1. Introduction

This program has benefited greatly through previous restructuring, which has been extremely constructive. This restructuring has focussed research into a series of theme, which are currently allied to a range of strategic policy issues for MAFF (Table 1).

- Theme 1: Resource monitoring
- Theme 2: Prediction of change in species composition at different grazing intensities
- Theme 3: Measurement of *Calluna* performance in a range of situations partly to enable the MLURI hill farming model to be re-parametarized for England and Wales and to develop new models.
- Theme 4: Development of methodologies for the control of aggressive species that are deemed undesirable and the restoration of infested areas to a more desirable community.
- Theme 5: Information flow to users.

A major feature of the work in this program is the development of models that will aid decision-makers to carry out policy in the uplands. This is an essential part of the strategy because any impact in the uplands will occur at a very slow rate, often taking decades to see the full impact. Thus, models are needed to be able to predict animal offtake and hence nutrition as well as species change, occurring as a result of Agri-environment scheme implementation.

2. General comments

In general, most projects visited appear to be well managed, and apart from where otherwise stated in Appendix I, and noted below in recommendations, are reaching milestones.

Moreover, the projects are sensibly tackling relevant policy areas for MAFF and there is a real attempt across the board to go beyond the site-specific study to produce generic information which is applicable across the range of regional variation across England and Wales (Table 2). This link to the countrywide level of information provision has been done through: (1) the use of a multi-site experimental/survey approach, (2) the development of generic models and (3) a combination of both.

3. Areas of concern

In the previous report concern was expressed (Marrs 1998) that, whilst the work is good, it is not accessible to either the scientific community or end users. For all projects there is a need to ensure that publication of results occurs, both in refereed scientific literature and in other ways to get the information across to end users. Whilst there has been considerable progress in two areas (a) the running of workshops (BD1217) and (b) publishing in appropriate grey literature (Association of Applied Biologist's York conference - March 2000: *Managing Vegetation in Changing Landscapes*), there has been relatively little progress in publishing in peer-reviewed journals. It is suggested that all project leaders be reminded that publication in peer-reviewed journals is expected, where possible. This will ensure that (a) the work is properly refereed by independent assessors and (b) the high-quality of research done within the Assessment Unit is advertised to a wider audience in this country and abroad, and makes the maximum impact. A milestone may need to be added to each contract to this effect, or should be included in all new contracts. The costs of this should be intrinsic within any contract.

3.1 Cross border difficulties

There is also concern that there is not enough collaboration between specialists in the three countries where upland research is being done (England & Wales - MAFF; Scotland - SERAD; Northern Ireland). This is a particular problem for the Uplands Assessment Unit because large amounts of upland agriculture are done in Scotland and Ireland. From a scientific viewpoint, this split between funding and policy agencies is not helpful because in some cases research is being funded by MAFF under this program, which has, either already been done, or similar approaches have already been developed elsewhere. One area where progress could be made in this area is to ensure circulation of research reports between country agencies, perhaps via the web.

An example of where there have been difficulties has been in the development of Decision Support Tools or models. MLURI, essentially through Scottish Office funding, are developing a model that hitherto has been based solely on Scottish data. Part of the remit of this program (BD1203 and BD 1215) has been to try and produce data that will feed into MLURI models. Unfortunately the model development with the English and Welsh data has not progressed as far as expected, and a decision will need to be made as to how to proceed (see below). With hindsight it might have been better to joint fund model development and data collection across the UK from the start.



Even when these new data are included into a working model it may not be applicable to Northern Ireland.

3.2 Need for countrywide studies and model development

There are important regional and national differences in vegetation, agricultural practices, linkages with other land users (eg sporting interests) and policy implementation. Thus, it is essential when developing research programs for working in the uplands to have a regional spread of sites, and model development that can account for a wide range of management practices under a range of schemes. These should in an ideal world cover existing prescriptions but also be flexible enough to cover new schemes, and also additional targets. An example of a new scheme would be the Tir Gofal one in Wales, and hopefully experience drawn from this program will be able to be used to predict the impacts of this new scheme.

As vegetation change is slow in the uplands, one of the main aims of the programme must be the development of predictive models. However, models must be based on reality, and must be validated against real data through time. This is particularly important if there are infrequent climatic events that severely damage vegetation. A long-term view is, therefore, an essential prerequisite for this programme.

The relatively new policy requirements for Biodiversity Action Plans and Biodiversity Targets will be aided by development of such models both in predicting potential performance and acting as a benchmark to see if the targets are being achieved.

4. Areas where effort should be concentrated/decisions made

Theme 1: Vegetation monitoring

This work done under this contract (BD1225) was a pilot study was of a routine administrative\technical nature rather than a scientific project. The work done, collecting information on the feasibility of using aerial photographs to monitor change in *Calluna* moorland, was sound and achieved its objectives. However, the project did not really produce any new insights, rather it showed that a historical survey job could be achieved. There are many examples of such approaches in the literature, and it might be worth considering whether new work in this field should either:

- (a) be end-user driven, where a customer wishes a job done and pays for it, in which case it should not be under this programme, or
- (b) be dictated by needs for such information at the policy or strategic level, in which case a much large appreciation of remote sensing and GIS activities may need to be reviewed and tested. Much of the expertise to do this work is available already within ADAS, ITE, various Universities etc.

There is no convincing case for continuing with research in this area unless there are much stronger policy needs than are obvious in the project covered by this review.

Theme 2: Prediction of change in species composition at different grazing intensities

Following criticism in the 1999 review the feeding blocks study (BD1216) was given special attention. It is a pleasure to report that this study has been well done, is strongly focused using good techniques and is producing results. The range of impacts measured during the study may not all show differences but they cover a range of sensitivities to pick up coarse and possible subtle changes.

The cellular automata modelling in BD1211 and BD1218 is exciting, but the scientists involved should ensure they collaborate with other specialists, for example Dr J Silvertown (OU), Dr Andrea Britton (MLURI), Professor P Grime (University of Sheffield). The most important development to come from this approach would be the development of a generic, site-specific cellular automata model where:

User inputs the aerial photographs, map data, vegetation and stocking rates in GIS



A Cellular automata is created based on real data



The user inputs policy scenarios



The Cellular automata is run as appropriate



The changes are viewed in relation to real land in GIS.

This must be the way forward for delivering this work to end-users. It would be difficult to achieve but I suspect progress could be made if the experience of the three groups involved in CA model development in the uplands (ADAS, Liverpool and MLURI) could be pooled. This might be risky to develop such a multi-organisation study, given previous difficulties with output delivery, but the benefits could be enormous.

Theme 3: Measurement of *Calluna* performance (BD1203 and BD1215)

This work has reached a cross-roads and decisions need to be made about how to proceed with the development of models for predicting vegetation biomass and production. The situation is that there have been many difficulties, which have prevented the full development of the MLURI model for England and Wales (detailed in Appendix I), briefly:

1. The basic structure of the MLURI model has evolved from the original Hill Management Grazing Model (mentioned in the BD1203) contract to HILLPLAN, this is an inevitable fact that science progresses. Future development of HILLPLAN will include the development of a Decision Support Tool that can be used directly by Policy Makers and Advisory Staff.
2. It was agreed at the Program Advisor's meeting in 1998 at Wolverhampton that it was sensible for model development to be based on HILLPLAN.
3. So far the data collected for England and Wales are sound and of high quality but have not been included in HILLPLAN yet.
4. The new HILLPLAN model needs to be tailored to answer specific policy user requirements. It is being tested at the moment with the SERAD and is still under development.

Thus, at present the MLURI HILLPLAN model is not suitable for use in England and Wales. It is recommended that the data collected under BD1203 should be included into the HILLPLAN database.

However, this on its own will not provide a Decision Support Tool (DSS) that will be useable in England and Wales. Part of the development that is currently being done by MLURI is to develop a DSS that is directly tailored to the needs of the end-users (SERAD advisors). The development might not need the requirements of users elsewhere.

There are a range of options, these are:

- (a) Include the England and Wales data in the HILLPLAN database and leave it at that; at present only the *Calluna* data will be included in HILLPLAN via the HEATHMOD sub model.
- (b) To contract MLURI to develop HILLPLAN as a DSS for England and Wales concurrently with the one being developed for Scotland.
- (c) To delay a decision until the DSS is working in prototype form for Scotland, and then contract MLURI to extend the development of HILLPLAN as a DSS for England and Wales

If HILLPLAN is developed for England and Wales then it should be tested on the Redesdale and Pwllpeiran datasets, which was one of the original intentions implicit in projects BD1211 and BD1218.

Option c is the fail-safe scenario, once the model is developed for Scotland then its suitability can be assessed formally and further development contracted.

Theme 3: Development of methodologies for the control of aggressive species that are deemed undesirable and the restoration of infested areas to a more desirable community.

The project to develop myco-herbicides (BDBD1224) for bracken control has produced disappointing results, and the project has now finished. The scientific work done under the project was excellent but whilst damage could be inflicted on the fronds, it was not sufficient to kill the bracken. Thus, it is no where near commercial development.

The integrated bracken control project and *Molinia* control projects (BS1219 and BD1226) are in mid term and are progressing well.

Theme 5 Information flow to users

At the annual Advisor's Meeting (BD1223) some concern was expressed that there was not enough transfer of information to users. Whilst ADAS have a contract (BD1217) to help transfer knowledge, it strictly applies only to ADAS work and not to other researchers in the program, although everyone has co-operated where possible in Workshops etc. However, this is one area information flow from users is sorely needed. Some form of joint forum is needed to determine (a) what advice and recommendations should be developed (prioritising), (b) how they should be advertised to users, and (c) whether any advice given is useful. The Internet could be a useful medium for this.

It might be worth linking some aspects of the knowledge transfer project (BD1217) to the "Demonstration Moors Project", which is run by the Heather Trust. Some joint activity here would be beneficial.

5. Recommendations on existing research projects

- The *Molinia* experiment at Redesdale requires at least another two years monitoring before the data will be publishable, but a milestone regarding publication should be added to this project.
- In the Redesdale study on regeneration after burning there needs to be a clarification and if necessary a separation of responsibilities between ADAS and MLURI, especially on publication of results. A new milestone is needed on the ADAS project.
- Develop collaboration between ADAS/Liverpool on the use of variation partitioning in CANOCO to separate the effects of environmental variables on species trends. A new milestone and perhaps additional funding/redirection may be needed.
- A decision is needed on how to proceed with the MLURI model for England and Wales, if it is continued it needs to be validated at Redesdale and Pwllpeiran.
- Publish scientific papers from most contracts. Milestones needed.
- The Upland Assessor should be encouraged to liaise across Scotland and Northern Ireland, and more scientists from these countries should be invited to the annual meeting.
- A new mechanism for delivering Technology Transfer should be considered.
- A link with the Heather Trust's Demonstration Moor project should be encouraged.

6. Gaps in the Programme, areas for future research activity

Short-term priorities

- There are few links with ESA monitoring data on species change. Whilst it is likely that results from the monitoring will take many years to detect there is scope for a pilot project to investigate ways of analysing these data and developing methodologies, prior to full scale analysis and modelling. Two methodologies have been developed: (a) by ADAS using a combination of techniques but including the use of functional types; (b) by Liverpool, which is based on multivariate methods. There would be scope for a joint study to test the usefulness of both approaches on a test ESA dataset, and then to develop computerised monitoring systems.
- There is almost no research on burning moorlands in England and Wales; this is a serious omission. There is a school of thought that believes burning is impossible in some areas, but this remains to be tested.
- Bracken control is often done by aerial spraying with asulam. There have been potential problems this year with asulam being reported in leachates and watercourses. This could be a real problem facing upland agriculture and more research is needed on this topic possibly in conjunction with the Environment Agency.
- Heath-grass mosaics, how do they degrade, what is the impacts of different grazing pressures, and how can *Calluna* be re-established once the grass becomes dominant.

Medium-term priorities

- There is no research on trees in the Uplands Assessment Unit, and this is one area of potential weakness. Tree and shrub plantings could have benefits for both agriculture and the environment, apart from aesthetics, economics and shelter trees could focus as a mechanism for the biological control of bracken as well as introducing a more interesting upland environment.
- There is almost no research on the effects of pollutants on upland communities within the programme; although there is work done elsewhere on nitrogen, or the use of pesticides (especially asulam use for bracken control and its impacts on rare species) or directly on the impact that climate change might have on upland communities (link with some TIGER projects and Marris & Pakeman's work on bracken).

- A socio-economic link to the communities which farm the uplands. At present there is necessarily a top-down approach through agri-environments schemes, but it would be useful to assess how these policies are viewed by the farming communities and by other who live, work and visit these areas.

Table 1. Linking of the four main research themes to MAFF policy issues

Theme	Title	Policy issues
1	Resource monitoring	<ul style="list-style-type: none"> • Historical monitoring of change in ESAs and other areas where <i>Calluna</i> is under threat. • Setting baselines
2	Prediction of change in species composition at different grazing intensities	<ul style="list-style-type: none"> • Grazing levels in ESAs • Prediction of changing species composition in relation to changing grazing patterns. • Producing usable predictive models for both farmers and policy makers <ul style="list-style-type: none"> ⇒ MLURI HILLPLAN Model ⇒ Cellular Automata/GIS
3	Measurement of <i>Calluna</i> performance in a range of situations partly to enable the MLURI hill farming model to re-parametarized for England and Wales and to develop new models.	<ul style="list-style-type: none"> • Assessing productivity of vegetation, and hence sheep across England and Wales • Assessing recovery potential of suppressed heather. • Assessing methods of improving the distribution of grazing pressure across moorland, improve overall grazing/vegetation use efficiency • Producing usable predictive models for both farmers and policy makers <ul style="list-style-type: none"> ⇒ MLURI HILLPLAN
4	Development of methodologies for the control of aggressive species that are deemed undesirable and the restoration of infested areas to a more desirable community.	<ul style="list-style-type: none"> • Development of strategies of the control of important weed species in the uplands • Bracken in particular has a high political profile for a number of reasons: <ul style="list-style-type: none"> ⇒ poisonous to stock ⇒ reduced agricultural productivity ⇒ reduced conservation interest ⇒ effects on human health ? • Integrating weed control into whole farm/estate management including vegetation restoration.
5	Information flow to users.	<ul style="list-style-type: none"> • Links to other scientists • Links to MAFF • Links to other governmental and non-governmental organisations • Links to farmers and other end users • Links to the public

Table 2. Assessment of the scope of the projects in the Upland Assessment Unit beyond the study site

Theme	Project	Site specific data	Regionally collected data	Extension beyond site to countrywide scale through modelling
1	BD1211	√		√
	BD1218	√		√
2	BD1203		√	√
	BD1215		√	√
	BD1216	√		
3	BD1209		√	√
	BD0506	√	planned but not implemented	
	BD1219		√	
4	BD1206	n/a		
	BD1217			n/a

APPENDIX I. UPLANDS ASSESSMENT UNIT 1998 - Professor R H Marrs**1. Terms of reference**

The contractor will provide advice to MAFF on research projects being done within the Uplands Assessment Unit through:

- A check on the progress of all projects within the Assessment Unit by at least one annual visit.
- Produce a final report by the end of March 2000.
- Organise a meeting in January 2000 of contractors, MAFF, FRCA and other interested sponsors of research to review progress of the Assessment Unit, exchange information about the projects and facilitate co-ordination amongst the contractors.
- Advise MAFF on new research opportunities within the Assessment Unit during the year and/or at the annual meeting.
- Encourage the adoption of compatible and, where appropriate, uniform experimental methodology in all projects within the Assessment Unit.
- Active promotion of the objectives, methods and results of the Assessment unit in co-operation with research contractors and MAFF.

2. Description and classification of Projects within the Uplands Assessment Unit

The projects within the current Assessment Unit have undergone considerable review and some have been redirected over the past few years.

There have been several changes to the program since the last report in 1998, there are:

- A three-year extension to the *Molinia* control contract was agreed to maintain the monitoring of species change in some of the *Molinia* control experiments. (renumbered BD 1219)
- The Program Advisors project was extended for one year (renumbered BD1223).
- A one-year extension to the project testing mycoherbicides was awarded (renumbered BD 1224) was agreed, but this work has now formally ended.
- A small contract for new work has been let to ADAS (BD1225). This was a feasibility study of potential use of aerial photography to map moorland change
- A five-year extension to the integrated bracken control and moorland restoration contract (renumbered BD1226) was agreed with extended outputs

The list of projects covered by this review are noted with new numbering in Table 1 and the contractors involved are shown in Table 2.

The thematic approach adopted in the previous report (Marrs, 1998) has been maintained, with the addition of a new theme to cover resource monitoring (the new project BD1225). The scheme adopted previously appears sensible, with only one anomaly (BD1216 - feeding blocks study), which has been reclassified as being better placed within Theme 2 - Prediction of changes in species composition.

The revised classification is show in Table 3.

Table 1. New contracts ongoing beyond 1998/9; * approved in principle only in July 1998

Contractor	New code	Title	End Date	Annual Cost £ K			Total Cost 99-02 £ K
				99/ 00	00/ 01	01/ 02	
ADAS	BD1203	Heather biomass measurements	Mar 99	18	0	0	18
ADAS	BD1211	Vegetation change and <i>Calluna-Nardus</i> interactions in relations to spatial variation in grazing pressure on moorland	May 01	83	83	21	187
ADAS	BD1215	Extension to project BD0109: Suppression of heather by grazing	Mar 99	15	0	0	15
ADAS	BD1216	Feeding blocks for managing sheep distribution on upland moor: impacts on grazing level and <i>Calluna-Nardus</i> interaction	Mar 02	60	30	15	105
ADAS	BD1217	Communication of work on moorland management to land managers, policy advisors and the research community	May 01	20	17	6	43
ADAS	BD1218	The effects of spatial variation on sheep grazing on <i>Calluna vulgaris/ Molinia caerulea</i> interactions	Mar 01	52	38	13	103
HT	BD1219	The re-establishment of dwarf shrubs on moorland previously dominated by <i>Molinia</i>	Dec 00	15	15	5	35
ULP	BD1223	Programme advisor for the Uplands Assessment Unit	Nov 98	5	3	0	8
USC	BD1224	Development and field testing of a myco-herbicide for bracken control	Sept 99	17	0	0	17
ADAS	BD1225	Feasibility of mapping past dwarf-shrub heath extent from aerial photographs on Dartmoor and Bodmin Moor	Mar 99	10	0	0	10
ULP	BD1226 (inc BD1209)	Integrated bracken control and vegetation restoration: ongoing assessment with follow-up treatments	Mar 04	75	80	80	235
Totals				370	266	140	776

Table 2. Contractors involved in the MAFF Upland Assessment Unit, their abbreviations (Table 1) and the total amount funded per contractor

Abbreviation (Table 1)	Scientific Contact and Address	Total number of projects	Total funding 1999-2002 £ K
ADAS	Dr S Gardner ADAS Wolverhampton Woodthorne Wergs Road Wolverhampton WV6 8TQ	7	481
HT	Mr John Phillips The Heather Trust The Cross Kippen Stirlingshire FK8 3DS	1	35
ULP	Professor R H Marrs School of Biological Sciences, University of Liverpool, PO Box 147 Liverpool L69 3BX	2	243
MLURI	Dr John Milne (Sub-contractor/joint contractor) MLURI Craigiebuckler Aberdeen AB15 8QH	2 sub- contracts	
USC	Dr M N Burge University of Strathclyde Dept of Bioscience & Biotechnology University of Strathclyde Todd Centre 31 Taylor Street Glasgow G4 0NR	1	17

Table 3. Project allocation to Theme, along with the refocusing of renewed contracts

Theme	Current projects	Allocation of resources 1997-2003 £ K
1. Resource monitoring	BD1225	10
2. Prediction of change in species composition	BD1211 BD1216 BD1218	395
3. Measurement of <i>Calluna</i> performance	BD1203 BD1215	33
4. Weed control and restoration	BD1219 BD1224 BD1226	287
5. Information flow	BD1217 BD1223	51

Resource monitoring Prediction of change in
species composition Measurement of *Calluna* performance Weed control and restoration Information flow

Section 3: Visits to contractors and assessment of projects**3.1 Programme of activity**

Because of the diverse nature of the history of the projects they were assessed according to the following strategy:

- Reports of completed projects, which had not been received in time for the 1998 report (**Projects BD0111, BD0116 and BD0117**) are reviewed briefly as historical documents, as these projects are no longer contributing to the main focus of the programme (Section 3.2).
- All current projects (Table 3) have been assessed on the basis of the current project number (Section 3.3).

The main contractors have been visited according to the following schedule for both laboratory and field visits (Table 4).

Table 4. Timetable of visits to contractors in 1998

Theme	Current projects	Lab visit in 1999
1: Resource monitoring	BD1225	17 November
1: Prediction of change in species composition	BD1211 ADAS	25 August + 17 November
	BD1218 ADAS	25 August + 17 November
	MLURI sub-contractor	28 September
2: Measurement of <i>Calluna</i> performance	BD1203 ADAS	25 August + 17 November
	BD1215 ADAS	25 August + 17 November
	BD1216 ADAS	14 January
	MLURI sub-contractor	28 September
3: Weed control and moorland restoration	BD1219 HT	25 September
	BD1224 USC	na
	BD1226ULP	Conference 20-22 July - entire group met
4: Information flow	BD1217 ADAS	25 August + 17 November
	BD1223 ULP	n/a

A workshop where all contractor presents aspects of their work to an invited audience was held on 24th January at MAFF, Nobel House, London.

Invitations were sent to a large number of interested parties including MAFF ADAS, FRCA, representatives from conservation organisations (EN, CCW, SNH), and scientists from both Scotland and Northern Ireland.

3.2 Comments on historical projects

BD0111 ADAS The ranging behaviour, habitat use and impact of deer in Oak woods and Heather moors of Exmoor and the Quantock Hills **Dr Jochen Langbein**

This was a small-scale contribution to a much wider partnership to study the impact of deer on vegetation in the south-west. The partnership had at least another 10 contributors so the final study is much greater than would have been achieved from the MAFF contribution alone. As such it represents very good value for money.

However, this project is rather out of place within the current program, although it does have some relevance for the impacts of deer on heather moorland. A major focus of the conclusions are that deer management should be manipulated by Deer Management Groups to maximise the benefit of deer while minimising damage to agriculture, woodland or moorland.

As far as moorland is concerned it was difficult to separate the impacts of deer from the much larger numbers of sheep present; separating these effects was noted as an important area for further work. It might also be added that reductions in sheep numbers might provide additional available forage for increased deer numbers!

This work was apparently competently done and the report appears sound. However, this work is rather *ad hoc* and was to some extent different from the rest of the program. On the positive the collaborative nature of this work allowed drawdown of a large amount of resources to fund this work.

BD0116 ADAS A literature review of factors affecting the growth of heather **Dr Francis Kirkham**

This report reviews what is known about factors affecting *Calluna* growth, along with four substantive appendices looking at:

1. Factors influencing the growth of heather
2. Re-analysis of data of dry matter productivity of heather and the effect of grazing on it
3. The effect of nutrient inputs and grazing on the growth of heather
4. The relationship between biotic/environmental variables and heather grazing.

This is a very useful compendium of information because it not only surveys the literature but also summarises a lot of data held by three groups (ADAS/MLURI/ITE) that are unavailable in the general domain at present.

The project ran over budget, and all milestones were late. One milestone has not been met yet, the submission of a paper to a scientific journal. The journal chosen (*Advances in Ecological Research*) has been contacted to see if a review would be acceptable, but apparently no answer has been received. This journal is an ambitious target, and the reports will need considerable rewriting to get it accepted. However, having brought all this information together it is important that a publication be pursued.

Recommendation: Publication of this work in a refereed journal should be pursued (Milestone 04/02)

BD0117 ADAS Statistical assessment of techniques for monitoring species composition in upland plant communities **Dr Sarah Gardner**

This was a small-scale assessment of methodologies for monitoring species abundance. The work was slightly over budget and all milestones were achieved albeit late.

Four different methods for measuring species composition were compared for their ability to describe vegetation and vegetation change. The methods were (1) % cover and Domin, (2) first hits with cross wires, (3) species dominance within a gridded quadrat, and (4) occurrence of key species within a gridded quadrat. The problem with different recorders (very important in large scale studies - Sykes *et al.* (1983) was apparently not considered, and this would be extremely important in large scale monitoring assessment.

A further point is the rarity/dominance problem; the Domin scale was specifically designed for phytosociology, and the rankings were chosen to make sure that rare species were recorded and given additional weight; on the other hand the occurrence of key species will give no information on sub-ordinate rarities. Thus, the comparison is not a like for like one. Moreover, the Domin scale is non-linear and it is unwise to use them in any calculation unless they are transformed (Bannister, 1966), so any calculation with them may be spurious.

To some extent the method chosen for a given job should reflect the objectives. If a rapid phytosociological assessment is needed, Domin > visual cover or > gridded frequency > key species. Use of cross wires (essentially a point quadrat) has its own problems with subjectivity, and experienced operators are needed. Operator tiredness adds inaccuracies.

This work should have been included as part of the ESA monitoring work as part of protocol development and did not warrant a separate project.

Recommendation: Techniques that have been chosen on the basis of this project be continued, with the proviso that they will be better information for some things than others!

3.3 **Comments on current projects****3.3.1** **Theme 1: Resource monitoring**

BD1225 ADAS Feasibility of mapping past dwarf-shrub heath extent from aerial photographs from Dartmoor and Bodmin Moor **Graham Clarke**

This was a small-scale feasibility study designed to advise MAFF on the feasibility and estimated costs of aerial interpretation surveys of the extent of past-dwarf shrub heath vegetation in Dartmoor and Bodmin. The contract ran over-budget but produced a detailed and accurate catalogue of possible sources of aerial photography. It does not proceed to implementation, but this was not part of the brief.

The report is detailed and makes some good suggestions for measuring the changing distribution of dwarf-shrub heath in these two areas. It suggests that coverage from 1969 could be "to some extent ground verified using the 2nd LUS maps. Whilst this is the best that can be done the suggestions are sensible.

However, this contract is not really a scientific one, merely a data collation exercise. As such it was a pilot study to test the potential usefulness of the technique, which could be developed further. However, even if implemented the project is a technical exercise and does not necessarily add to knowledge about the use of aerial photographs of other types of imagery for monitoring purposes.

Recommendations: Projects that are of a data collection exercise as an aid to management should be funded outside the scientific program, this project would be better placed within the Monitoring Budget for ESAs.

3.3.2 **Theme 2: Prediction of change in species composition**

BD1211 ADAS Vegetation change and *Calluna-Nardus* interactions in relation to spatial variation in grazing pressure on moorland **Dr Sarah Gardner**

This project has been derived from a separation and refocusing of research at Redesdale and Pwllpeiran. This project now solely focuses on the Pwllpeiran work on moorland where *Nardus* is a problem. This work concentrates now on assessing the effects of different stocking levels (Tier 1 and Tier 2 prescriptions), and has been analysed at three scales; NVC, Site-specific assemblages, species level. It uses the same analytical methods as Redesdale viz Fuzzy Logic, multivariate analysis and assessment of trends with respect to plotted NVC classes. There is also an experiment with 5 seasonal grazing treatments reflecting Tier 1 and Tier 2 prescriptions over a full years grazing, but concentrated into either 4 or 7 month periods and contrasted with an ungrazed control .

BD1218 ADAS Assessment of the effects of spatial variation on sheep grazing on *Calluna vulgaris*/
Molinia caerulea interactions **Dr Sarah Gardner**

This project has been derived from a separation and refocusing of BD0106 which covered both research at Redesdale and Pwllpeiran. This project now solely focuses on the Redesdale work.

There were originally four parts to this project:

- Study 1: A heft scale comparison of two stocking rates on moorland with both *Calluna* and *Molinia*.
- Study 2: A replicated experiment aimed at developing techniques to control *Molinia* and promote *Calluna*.
- Study 3: An experiment to investigate the effect of burning on the re-establishment of *Calluna*; this part is joint work with MLURI.
- Study 4 A major part of the heft scale comparison was to test the usefulness of the MLURI model

Of these:

- Study 2; The *Molinia* experiment requires at least another year's monitoring, before the data will be fully publishable. However, a poster paper has been accepted for publication in the Association of Applied Biologists conference at York in March.

Recommendation: A milestone is needed to ensure that the full analysis is published in refereed journals.

- Study 3: The study on regeneration after burning has been done jointly with MLURI. There has been a separation of responsibilities between *Calluna* regeneration (MLURI) and floristics (ADAS). There needs to be clear identification of who does what and who is responsible for publishing the results.

Recommendation: A milestone is needed to ensure that the full analysis is published in refereed journals.

BD1218 and BD1211 together

In both newly-refocused projects other additional aims were included, this is not surprising since they will provide relatively long-term information on vegetation dynamics in two areas of upland Britain. The additional aims were:

- To develop a spatial “cellular automata” type model for *Calluna* and *Molinia/Nardus* moorland.
- There is scope for using CANOCO to assess the influence of environmental variables to determine which ones were the important controls on vegetation change.
- To use the field data to validate the model. The new MLURI model should be tested on the Redesdale and Pwllpeiran studies when the model is available.

There has been considerable progress in developing the cellular automata type models at the theoretical level, and they have provided useful insights into the ways that moorland might develop, depending on pattern etc. However, they are still in the early stages and the further development of this approach should be fruitful. A criticism of this approach, as with all CA models, is that they are essentially applicable only to hypothetical patches of land.

Recommendation: On target and waiting for more results with interest.

BD1216 ADAS Feeding blocks for managing sheep distribution on upland moor: impacts on grazing level and *Calluna-Nardus* interaction **Dr Sarah Gardner**

The aim of this project is to test whether feeding blocks can be used to shift the distribution of sheep and hence affect the vegetation structure and composition. The project is just starting using four sites in the Cambrian Mountains ESA and there is going to be before and after measurements of vegetation change.

There was considerable concern expressed at the start of this project about whether change could be expected to be picked up during the life of this contract. The staff concerned thought that it was likely. Concern was also expressed about the general methodology of comparing before and after measurements of a range of situations where the variation and differential responses might interfere with identifying trends.

Indeed the recommendation made in the 1998 review (Marrs 1998) was that this project should be carefully evaluated at the end of the first year. After two presentations I have been very impressed with the way that this project has been set up, encompassing both the use of feeding blocks to re-distribute sheep and more important to link this to a range of spatial scales through the use of spatial autocorrelations. This project has built substantially on research carried out by ADAS on ESA monitoring, where semi- variograms were used to investigate the effects of different scales of grazing patterns (spatial autocorrelations).

This project is still, however, in its early stages but already a platform paper has been accepted for the Association of Applied Biologists conference at York in March.

Recommendation: On target and waiting for more results with interest.

3.3.3 Theme 3: Measurement of *Calluna* performance

BD1203 ADAS Heather biomass measurements **Dr Francis Kirkham**

This project aimed to measure rates of biomass production for six moorland communities at a range of different upland areas with two major aims:

- To quantify the effects of environmental variables (climate, management and soil type) on the productivity of a range of plant communities.
- To collect data that would allow the MLURI Hill Grazing Model to be developed to fully accommodate upland farms in England and Wales.

These data are being collected according to a well-planned schedule, which was due to finish in 1998. The data have now been analysed and a paper prepared for publication; a platform paper has been accepted for the Association of Applied Biologists York meeting.

The report did, however, run over budget and one of the milestones has not been met properly. However, the project has delivered many of their milestones and targets, specifically it has brought together a very large and good dataset on biomass production across England and Wales, data not available hitherto. Moreover, a large number of statistical analyses have been done on these data relating production to various environmental factors. An atlas of productivity has also been prepared. In my view the atlas is less useful than the dataset, which is a major achievement.

The milestone, which has not been met so far, is the inclusion of these data into the MLURI model; there are several reasons for this, including:

1. A change in the model from the original Hill Management Grazing Model to HILLPLAN. The original contract called for inclusion of these data into the former, whilst all new work is now done by MLURI on the latter. This is sensible given that HILLPLAN is built on a much better engine and will be more adaptable to meeting the requirements of policy makers.
2. It was agreed at the Program Review meeting in the 1998 review in Wolverhampton that it was folly to continue with the original model milestone and that HILLPLAN was a more realistic and sensible target.
3. The costings allowed in the project were really insufficient to meet the development costs of serious model development.
4. The new HILLPLAN model needs to be tailored to answer specific policy user requirements. It is being tested at the moment with the SERAD and is still under development.
5. One of the difficulties that has beset this project and in last year's report was that data were not being analysed as they were being collected, rather the analysis was left to the last year. This was apparently planned at the outset to accommodate the contract cash flow. This is rather unwise and future contracts should be funded so that data analysis is done as the data are collected, so that trends can be checked, outliers or odd data points checked and perhaps the methodologies improved.
6. The link to the MLURI model was also planned to be done in the last year of the contract. As this is one of the most important reasons for carrying out the work it is a pity that it was not more heavily integrated into the data analysis.

It is likely that there will be two series of outputs:

- Series 1: Papers on the relationships between biomass and productivity in a range of plant communities of great importance in the upland and environmental factors.
- Series 2: The redeveloped MLURI HILLPLAN model is not as yet suitable for use in England and Wales. The data collected under this contract should be included into the HILLPLAN database as agreed but it is unlikely that further model development for England and Wales will be done under this contract. Some thought will need to be given to how HILLPLAN is implemented for English and Welsh conditions.

Recommendations: A milestone is needed to ensure that the scientific paper from this work is submitted (£5.8 K has been allocated for publication in 1998/9).

Some thought needs to be given to how to proceed with the development of the MLURI HILLPLAN model after the data from this project are included. At present only the *Calluna* data are being included, the data for the other species will not be included.

If HILLPLAN is developed for England and Wales it should be tested on the Redesdale and Pwllpeiran datasets.

BD1215 ADAS

Extension to project BD0109: Suppression of heather by grazing **Dr Francis Kirkham**

This project aims to develop a model to predict the long-term patterns of utilisation on the suppression of heather. In order to do this a joint project has been developed between ADAS and MLURI, and essentially the aim is to extend the range of a model already produced by MLURI. This model has been based on relatively few data and the aim of this project is to extend the data available within the model, and to be able to better predict threshold utilisation values that can be used to indicate suppression. There were four subsidiary aims:

- To assess effects of different levels of *Calluna* utilisation on subsequent structure and cover of *Calluna* plants.

- To quantify the effects of geographical location, *Calluna*, soil and climate on the relationship between utilisation and subsequent productivity.
- To compare the different levels of grazing by grazing and clipping.
- To quantify the magnitude and extent of delayed effects of grazing at different intensities on subsequent *Calluna* growth.

An important output is the production of multidimensional look-up tables to define grazing threshold that can be sustained before suppression occurs; these will accommodate any interaction with bio-climatic zones.

Unfortunately the outputs from this project have not met their expectations. This is not to say that the data have been collected badly, it is just the results allowed only tentative conclusions to be drawn. This is unfortunate but the data should still be publishable and a paper based on allied work by MLURI is now ready to be submitted.

Recommendation: The publication of a scientific paper(s) from this work should be encouraged.

3.3.4 Theme 4: Weed control and moorland restoration

BD1209 ULP Integrated bracken control and vegetation restoration: ongoing assessment with follow-up treatments **Professor Rob Marrs**

This project aims to investigate integrated methods for bracken control and builds on twenty years research on the topic. The current project is a continuation of two earlier ones which set up a series of long term experiments testing a wide range of approaches to bracken control and moorland/grassland restoration. In the previous contract there was also a large-scale assessment of the effects of bracken control. The experimental work is spread across England and Wales and in most experiments there is a common core of replicated bracken control treatments, coupled with site-specific treatments appropriate to the vegetation present. Seven years data on bracken performance and vegetation restoration have been collected and this autumn effects on rhizome performance will also be measured. Most milestones have been met to date, and additional work included which was not part of the original project, including: intensive multivariate modelling and analysis of the seedbanks at two of the experimental sites. In the previous report there was one objective outstanding, in that rhizome assessments could only be made in 4 out of the 7 sites as a result of the severe inclement weather in autumn 1998. In the first year of the new contract this has been partially redressed, in that a further two experiments were sampled in 1999, plus half of one of the experiments sampled in 1998 (N Wales). In 2000 the final site will be sampled, plus the other half of the N Wales experiment. This approach provides a lot more information on the impacts on rhizomes, because it gives comparable data through time for one of the sites.

A major feature of this research has been the development of novel techniques for the analysis of the complex datasets found in both survey and experiments; these include analysis of variance, multivariate grouping of data according to upland vegetation types, canonical correspondence analysis, HOF modelling, spatial autocorrelation and variation partitioning. These approaches have allowed us to partial out the effects of space, treatment applied and other environmental variables from the analyses and assess their significance. A number of publications have already been published and it is expected there will be many more.

The new contract will also use the chronosequence approach developed in Phase 1 of the contract: new sites, which were sprayed last year have been followed from the time of spraying. These will effectively be Year nought measurements. Major chronosequence survey will start in 2000.

Recommendation: On target and waiting for more results with interest.

BD0506 USC Development and field testing of a myco-herbicide for bracken control **Dr Mike Burge**

This is a potentially very exciting project, the development of a fungal pathogen to attack bracken. The pathogen is *Asochyta pteridis*, the agent of curl tip. Dr Burge has been working on this project for many years and has been consistently improving the effect. This current project has involved a considerable amount of technique development, especially in spray technology (now using air-assisted CDA sprayer) with a range of emulsions and additives. The emulsions are critical so that the fungal spores remain in a moist environment on the leaf for as long as possible and additives such as low concentrations of ioxynyl are included to interfere with cell wall lignification.

This work has been carried out in a very systematic way and to a very high degree of technical competence. In the final year of the original project the field trials aim to:

- assess different emulsions
- compare different application volumes

- test application to upper and lower sides of the rachis
- test repeat applications
- assess effects of different spore concentrations
- investigate the effects of different herbicide adjuvant doses
- investigate the interaction with crushing.

The year extension was designed to:

- Determine whether there was systematic movement of fungus within the plant in the laboratory
- Complete regional field trials

All milestones were met on time.

The results from the laboratory studies on pathogen movement suggested that there was some movement in the tissues, but unfortunately not to the rhizome.

The results of the field trials have been disappointing. The bracken fronds are certainly affected but many are not killed and the affected fronds can outgrow the infection. Moreover, there appears to be little in the way of carry over between seasons making this approach unsuitable as a practical control measure at present.

This work has been done to a very high standard, and there is no doubt that some of this work is publishable, but unfortunately the development of myco-herbicides for bracken control is still a long way off.

The project has now finished.

Recommendation: This was an excellent idea and the work has been done to an excellent standard. Unfortunately it has just not worked at a level to proceed to implementation. This area of work should now end until there are major breakthroughs elsewhere in myco-herbicide technology.

BD1219 HT The re-establishment of dwarf shrubs on moorland previously dominated by *Molinia* **Mr John Phillips**

This project was approved at the end of 1998 and two seasons field work has been completed from the large scale *Molinia* control experiments set up in Phase 1. The award of the contract delayed the first year's report and the second will be produced at the same time.

During 1999 three papers have been prepared from the original project, one has been published, one has been accepted and another is under review, all in refereed journals.

Recommendation: Project is on schedule, await final report in 2000/2001.

3.3.5 Theme 5: Information flow

BD1217 ADAS Communication of work on moorland management to land managers, policy advisors and the research community **Dr Sarah Gardner**

This project is on schedule and the first workshop on *Upland Management* was held at the University of Lancaster in 1998. The next will be held in March 2000 as an additional meeting at the Association of Applied Biologists meeting at York. Two projects (at least) will be represented.

There are also a large number of suggestions for Technical Guidelines, which have been made.

It is difficult to see how the value of this project can be assessed without some form of survey of the user community.

This is one area where a mechanism is needed, to co-ordinate (a) what advice and recommendations should be developed (prioritising), (b) how it should be tackled, and (c) whether it works.

Recommendations: This project is on schedule.

Evaluation of the impact of both workshops and Guidelines should be implemented.

A mechanism be developed (forum or website) for technology transfer for the Assessment Unit as a whole

BD1206 ULPProgramme advisor for the Uplands Assessment Unit **Professor Rob Marrs**

This is the project for assessing the Upland Assessment Unit, this is the final report.

This is the second year of assessing the Upland Research in this way and a great deal of experience has been gained. First, the decision to visit all groups twice was not possible this year because of the delay to the start date of the contract, so field visits were not done. This is a pity and should be rectified in future years. Two visits were made to ADAS, one of which included a partial field day.

It is better that the assessor visits every group twice, and where possible arrange a field visit to see the work being done on site. I believe this is essential and it should be made implicit in the terms of reference that field visits should be included as part of the assessment.

Following last years recommendations, the annual meeting was held in London and two speakers external to the program were included. Mike Burke from ADAS talked about his work on ESAs and Jim McAdam's group talked about experience of monitoring ESAs in N Ireland.

In addition, the Program advisor was co-opted on to the organising committee of the Association of Applied Biologists conference to be held in York next year, primarily to organise an uplands session. Four platform papers and one poster paper will be presented at this meeting (Le Duc, Pakeman & Marrs; Wildig; Kirkham & Milne; Ross), which will help advertise the high quality work that is being done in the Uplands Assessment Unit.

A workshop meeting to promulgate best practice in moorland restoration carried out as part of BD 1217 will be held at the end of this conference.

Recommendations: Field visits should be included as part of the assessment process.

Meetings should be in London and should include scientists, managers and policy makers

External speakers should be continued where possible.

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Project
title

Programme advisor for the Uplands Assessment Unit

MAFF
project code

BD1223

Scientific report (maximum 20 sides A4)

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