Environmental RTDI Programme 2000–2006

IDENTIFICATION OF ENVIRONMENTAL VARIABLES FOR USE IN MONITORING FOR THE EVALUATION OF THE RURAL ENVIRONMENT PROTECTION SCHEME (REPS)

(2001-EEA/DS10-M2)

FINAL REPORT

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by
Teagasc
and
Royal College of Surgeons in Ireland

Authors:
John A. Finn, Brendan Kavanagh and Maeve Flynn

ENVIRONMENTAL PROTECTION AGENCY
An Ghníomhaireacht um Chaomhnú Comhshaoil
PO Box 3000, Johnstown Castle, Co.Wexford, Ireland

Telephone: +353-53-60600 Fax: +353-53-60699
Email: info@epa.ie Website: www.epa.ie

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Details of project partners

Dr John A. Finn
Teagasc
Environmental Research Section
Johnstown Castle
Wexford
Tel: 053 71273
E-mail: jfinn@johnstown.teagasc.ie

Dr Brendan Kavanagh
Biology Division
Royal College of Surgeons in Ireland
St Stephen's Green
Dublin 2
Tel: 01 402 2333
E-mail: bpkavanagh@rcsi.ie

Dr Maeve Flynn
Biology Division
Royal College of Surgeons in Ireland
St Stephen's Green
Dublin 2

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Executive Summary

This study aimed to identify and select environmental indicators for a monitoring programme that may be integrated into an environmental evaluation of Ireland's agri-environmental scheme. This was achieved primarily by reviewing a range of agri-environmental indicators and suggesting indicators that would be appropriate to the Rural Environment Protection Scheme (REPS).

For each of the categories landscape, biodiversity and agronomy, indicators were selected according to three tiers (basic, moderate and advanced) that correspond to differences in the rigour, quality or requirements of the following issues: data availability; expertise required; logistical effort; quality of information, and; validity of causal mechanisms.

Consultation with selected stakeholders indicated quite widespread agreement that the selected indicators reflected the environmental performance that would be expected from the REPS.

This study discussed the interdependent relationship among agri-environmental scheme design and objective-setting, selection of indicators, monitoring and evaluation. If the selected agri-environmental indicators (or others) are to be used to monitor the environmental performance of the REPS, then this study clearly highlighted the importance of identifying specific and measurable performance targets for chosen indicators.

1 Project background, aims and objectives

1.1 Introduction

The Rural Environment Protection Scheme (REPS) was established in Ireland in 1994 and is a voluntary national scheme. It is designed to reward farmers for farming in an environmentally friendly manner and to bring about environmental improvements on participating farms.

The specific aim of the study was to identify and select quantitative environmental attributes for a monitoring programme that may be integrated into an environmental evaluation of Ireland's agri-environmental scheme. This was achieved primarily by reviewing a range of agri-environmental indicators and suggesting indicators that would be appropriate for monitoring the REPS.

The study conducted a desk review to collate information on current best practice in monitoring for environmental quality. A Project Group (comprising representatives from the Environmental Protection Agency [EPA], Department of Agriculture and Food [DAF], Teagasc, and the project supervisors) advised on the ongoing development of the project. There was a consultation process with national experts, and with a selection of stakeholder organisations with an interest in monitoring the environmental impact of the REPS.

1.2 Objectives of the study

The objectives of the study were as follows:

Stage 1. Conduct a desk review and prepare a draft report:

- Identify a range of specific, measurable environmental attributes from other relevant monitoring programmes or from relevant scientific literature;
- Identify appropriate evaluation models (e.g. Fig. 2.1);
- Identify and justify environmental attributes that are appropriate to the REPS objectives and/or measures;

- Identify/suggest targets for attributes that are appropriate to the REPS objectives and/or measures;

- Identify databases of relevant environmental variables and briefly assess their availability and potential relevance to a monitoring programme.

Stage 2. Review of the draft report by the Project Group.

Stage 3. Review of the draft report by national experts.

Stage 4. Review of the draft report by stakeholders.

Stage 5. Revise the desk review and submit the Final Report.

1.3 Scope of the study

This study aimed to identify relevant and measurable environmental attributes and their targets, and significantly advance the ability to implement a monitoring programme for the REPS.

The scope of the study did *not* directly address the design and implementation of a monitoring programme, which would require a detailed consideration of the sampling protocols, the experimental design of a sampling programme, and the data management and statistical treatment of the collected data.

1.4 The Agri-Environment Regulation

The 1992 Common Agricultural Policy (CAP) included a requirement that member states establish agri-environmental schemes (the Agri-Environment Regulation, Council Regulation No. [EEC] 2078/92). Following the CAP reforms in Agenda 2000, agri-environment schemes are now included as Chapter 6 in the composite Rural Development Regulation (1257/99).

For example, the listed objectives aim to **promote**:

- ways of using agricultural land which are compatible with the protection and improvement of the environment, the landscape and its features, natural resources, the soil, and genetic diversity;

- an environmentally friendly extensification of farming and management of low-intensity pasture systems;
- the conservation of high nature-value farmed environments which are under threat;
- the upkeep of the landscape and historical features on agricultural land;
- the use of environmental planning in farming practice.

The response to the agri-environment regulation varied across the member states, with some countries implementing a variety of regional schemes while others focused on developing single national schemes. Deblitz and Plankl (1998) provide a comprehensive synopsis of agri-environment schemes and measures operating in the European Union (EU); a brief synopsis is provided in Table 2 of Kleijn and Sutherland (2003).

The diversity of schemes, both national and regional, can be explained by Article 3 of the regulation, which required that member states implement the regulation in accordance with their specific needs, reflecting their diversity of environmental situations, natural conditions and agricultural structures. By 1999, about 20% of the total agricultural area within the EU was under agri-environmental agreements at a cost of about €3 billion per annum.

A core principle of agri-environment schemes is that farmers are paid in recognition of the cost and loss of income incurred in providing an environmental service that goes beyond *good farming practice* (GFP). Definitions of GFP have been drawn up and approved by the European Commission. Under the Rural Development Regulation, a clear distinction is made between rewarding farmers for accepting obligations beyond an accepted environmental baseline and other measures that focus on farming practices below the baseline. Thus, farmers must deliver some form of positive management in return for payments (Bignal and Baldock 2002). Environmental monitoring and evaluation permits an investigation of whether these benefits are being delivered.

Member states are obliged (Article 16, Regulation [EC] No. 746/96) to implement monitoring and evaluation of *environmental, agricultural and socio-economic* impacts under their respective agri-environmental programmes.

For an overview, see 'Impact of agri-environment measures' at **http://europa.eu.int/comm/agriculture/envir/report/en/2078_en/report.htm**.

For more detailed discussion see **http://europa.eu.int/comm/agriculture/rur/eval/index_en.htm**, and in particular see the following documents at that location:

- Guidelines for the mid term evaluation of rural development programmes 2000-2006;
- Common Evaluation Questions with Criteria and Indicators;
- Evaluation of rural development programmes 2000-2006 supported from the European Agriculture Guidance and Guarantee Fund.

Currently, the Common Evaluation Questions are used to evaluate the agri-environmental programme across EU member states. Although an important aid to evaluation, the Common Evaluation Questions are aimed at a more generic evaluation and are intended to be applicable to any EU scheme. Additional questions may be required to directly reflect the effectiveness of schemes, especially when most national schemes are customised to address specific issues.

There are relatively few published references to specific, measurable indicators for individual agri-environment programmes in EU member states. However, international agencies such as the Organisation for Economic Cooperation and Development (OECD 2001), and individual countries such as the UK (MAFF 2000), Canada (McRae *et al*. 2000) and Finland (MTT 2002) have published reports on the development of agri-environment indicators.

Evaluation of the environmental effectiveness of agri-environmental policy is becoming increasingly important in order to satisfy EU requirements, to demonstrate value-for-money to taxpayers, and to avoid accusations of trade distortion. The development of monitoring methods and the implementation of a more

comprehensive national-scale monitoring scheme may further the long-term interests of farmer participation and reward from agri-environmental schemes.

1.5 The Rural Environment Protection Scheme (REPS)

REPS was established in Ireland in 1994, and has the following objectives:

- to establish farming practices and production methods which reflect the increasing concern for conservation, landscape protection and wider environmental problems;
- to protect wildlife habitats and endangered species of flora and fauna;
- to produce quality food in an extensive and environmentally friendly manner.

The scheme consists of 11 compulsory measures and additional supplementary measures, which together aim to achieve the above objectives (Table 1.1). Measure A specifically addresses targeted land of high conservation value (designated as Natural Heritage Area or Special Area of Conservation) and is compulsory where such lands occur.

Table 1.1. REPS measures (Department of Agriculture and Food 2000a).

Compulsory measures	
Measure 1	Nutrient management plan
Measure 2	Grassland management plan
Measure 3	Protect and maintain watercourses and wells
Measure 4	Retain wildlife habitats
Measure 5	Maintain farm and field boundaries
Measure 6	Cease using herbicides, pesticides and fertilisers in and around hedgerows, ponds and streams
Measure 7	Protect features of historical and archaeological interest
Measure 8	Maintain and improve the visual appearance of farm and farmyard
Measure 9	Produce tillage crops without growth regulators
Measure 10	Become familiar with environmentally friendly farming practice
Measure 11	Keep such farm and environmental records as may be prescribed by the Minister

Measure A	Conservation of natural heritage This measure is targeted at commonage and land designated as either a Natural Heritage Area (NHA) or Special Area of Conservation (SAC). Measure A is obligatory for REPS farmers, but may be adopted for target land outside the general REPS programme.

Supplementary measures
Rearing animals of local breeds in danger of extinction
Long-term set-aside
Organic farming

Over the duration of the REPS 1 (1994–99), about 45,500 farms (1.6 million ha, ca 33% of utilised agricultural area, UAA) participated and about €627 million was expended on the scheme by the end of 2000. By 2003, REPS 2 had about 45,000 participating farms (an area of 1.12 million ha, ca 23% of UAA) and €326.8 million had been spent on the first four years of REPS 2.

1.6 Evaluation of environmental performance of the REPS

Since its inception in 1994, the REPS has been subjected to two evaluation exercises, one in 1999 and another in 2003. The full report of the latter review is available on the Department of Agriculture and Food website at **http://www.agriculture.gov.ie** under the section 'C.A.P.' In addition there are annual inspections of the scheme to evaluate compliance by selected participants.

In the first evaluation in 1999, the chapter 'Environmental impact of the REP Scheme' commented that:

> A weakness of the implementation of the REP Scheme to date has been the absence of comprehensive environmental baseline data ... this is unfortunate as it appears that the Scheme has been well designed and well promoted amongst the farming community. Instead, the evaluation has had to fall back largely on the requirements made of farmers in the individual REP Scheme plans ... there is a need for baseline data and monitoring of the Measures dealing with habitat and landscape.
>
> (Department of Agriculture, Food and Rural Development 1999: 52, 53)

The Department of Agriculture and Food has used an evaluation system based on available data for its 1999 and 2003 reviews of the REPS. A number of Irish publications have discussed the development of agri-environmental indicators for an evaluation. Lehane (1999) published a discussion document on key national agri-environmental indicators, several of which are of relevance to agriculture. Hickie (2000) reported on the development of a methodology for the assessment of the impacts of agriculture on the environment using agri-environmental indicators.

Since this first evaluation, there has been a growing pressure from non-governmental agencies (NGOs) and the public to provide more detailed information on the impact of the REPS on the agri-environment, biodiversity and the wider countryside (BirdWatch Ireland 1999, Hickie *et al.* 1999, Bohnsack and Carrucan 1999, An Taisce 2002, Feehan *et al*. 2002a,b, Gwyn *et al*. 2003). The recent report by An Taisce (2002) specifically discusses a framework for the enhancement of the monitoring and evaluation of REPS 2.

The task of identifying agri-environmental indicators with which to monitor the scheme in a retrospective manner is challenging. Nonetheless, it is an essential first step in establishing a more comprehensive monitoring programme with which to more directly evaluate environmental effectiveness of the specific agri-environmental objectives of the Irish scheme. This study aims, at least in part, to address these issues by suggesting a potential suite of appropriate indicators for a more comprehensive monitoring programme.

1.7 Focusing the project

In agreement with the Project Group, this study identified three major agri-environmental themes that encompass most of the agri-environmental aims of the REPS:

- Landscape
- Biodiversity
- Agronomy

This report examines the scope of indicators in the three categories of landscape, biodiversity and agronomy. There is some duplication of indicators between sections, for example a number of the indicators presented for landscape monitoring and evaluation overlap with indicators presented in the biodiversity section, particularly those referring to habitats. Such indicators are of additional value as they can provide data on more than one category simultaneously.

1.7.1 Landscape

Agricultural processes have shaped landscape development throughout Europe and Ireland. This has resulted in regional and national characteristics. The Irish landscape is characterised by its patchwork pattern of fields and field boundaries of hedgerows and stone walls. This *bocage* pattern is a highly valued landscape attribute in Ireland and other parts of Europe. Such traditional and semi-natural landscapes support much of the biodiversity associated with the agricultural environment. While traditional agricultural processes are responsible for different agricultural landscapes, more recent trends in agriculture conspire to alter and affect landscape features negatively.

Processes associated with areas of high agricultural productivity such as specialisation, reduction of crop diversity and expansion of field sizes can result in the loss of cultural features and a decrease of aesthetic amenities coupled with loss of biodiversity and increased abiotic environmental damages. Conversely, landscapes with low agricultural productivity can also suffer through the abandonment of agricultural production. In this case, traditional landscapes can be altered through processes such as inappropriate afforestation and natural succession resulting in loss of characteristic biodiversity (Piorr 2003).

Agri-environment schemes are an important tool in maintaining and protecting agricultural landscapes. At the very least, such schemes ensure the maintenance of existing features such as hedgerows, habitats, farm buildings and archaeological remains. The REPS aims to maintain and promote extensive farming practices that protect and maintain the general agricultural landscape. However, the REPS also provides for more specific management practices for habitats that would frequently occupy large areas of local landscapes, e.g. commonages, heathland, the Burren, coastal machair, etc. All of the REPS measures aim to contribute to landscape

maintenance and protection, some more directly than others. The visual attractiveness of the farmyard and farmed land is given considerable importance in the scheme.

The concept of 'landscape' is quite broad; therefore the selection of landscape indicators covered a wide range of topics including participation levels; land use and landscape composition; habitat diversity; archaeology; farmyard appearance; and farmyard wildlife.

1.7.2 Biodiversity

One of the main objectives of the REPS is to protect wildlife habitats and endangered species of flora and fauna, thus putting biodiversity concerns at the heart of the scheme. In addition, the conservation of genetic diversity (domestic breeds in danger of extinction) is targeted through a supplementary measure.

REPS aims at two main categories of habitats. Common farmland habitats include hedgerows, field margins, woodlands, watercourses etc. These habitats are widely distributed. These tend to be marginal to normal farming operations but harbour the majority of the biodiversity found on such farmland. Another category of farmland habitat includes rare farmland habitats and habitats of high conservation value (listed habitats in the REPS specifications, e.g. heathland, peatland, machair, species-rich meadows). These may be designated as NHAs or SACs, but not necessarily. In addition, farmland may be occupied by species of particular conservation interest that are locally distributed e.g. bats, corncrake, hen harrier, chough, lizard, the common frog, the marsh fritillary and a variety of plants (see Lucey and Doris, 2001).

The National Biodiversity Plan (DAHGI 2002) draws attention to the REPS as a 'potentially important instrument for harmonising farming with biodiversity ... A number of measures in relation to monitoring, evaluation and refinement of the scheme will be put in place in order to ensure that the maximum possible benefits accrue to biodiversity and the environment generally' (e.g. see Actions 57–64 of the National Biodiversity Plan). A future challenge for the REPS, and any consequent monitoring scheme, is to translate the aims of the National Biodiversity Plan into Biodiversity Action Plans at farm-scale level. Some advances have already been made with some NGOs, who are becoming increasingly involved in such initiatives e.g. BirdWatch Ireland's work on the corncrake.

The influence of the REPS on biodiversity can only be elucidated through the implementation of a specialised monitoring programme and subsequent evaluation. While stand-alone studies can provide valuable results and insights into the workings of the scheme (Dunford and Feehan 2001, Feehan *et al.* 2002a,b, Flynn *et al.* 2002, Aughney and Gormally 2002), a dedicated monitoring system would address the need to provide more specific data on a national scale and over a longer time period.

1.7.3 Agronomy

Agronomic practices are key mediators of agri-environmental impacts (both positive and negative). Therefore, indicators of agricultural inputs and management are a significant element of agri-environment evaluation. They provide information on changes in nutrient usage and management for environmental improvement. Moreover, such information tends to be more readily available through existing agricultural and farm surveys.

Efficient nutrient use is central to the REPS. The primary environmental objectives of the more prominent management practices are pollution control and nutrient management (e.g. Measures 1 and 2).

A fundamental test of the REPS is to identify its impact on water quality. However, a major challenge is to isolate the impact of the REPS from the multitude of other factors that affect water quality. Any positive impacts on water quality due to REPS farming practices can be masked by the effects of non-REPS farms, industrial discharges, sewage scheme discharges and runoff from roads and forestry plantations.

2 Monitoring of agri-environmental schemes

2.1 What does 'monitoring' mean?

A number of definitions of 'monitoring' are available, but some recurring themes are as follows:

- Firstly, monitoring requires the *a priori* setting of specific and measurable objectives and targets, against which the collected data can be compared.
- Secondly, the sampling design and strategy should be capable of collecting sufficient data to permit an unambiguous analysis of the data.
- Thirdly, comparison of the expected objectives and the collected data permits an objective evaluation of whether the recommended practices are having an impact and/or need to be modified (Fig. 2.1).

Thus, it should be clear that monitoring differs from a survey. A survey has been described as 'an exercise in which a set of qualitative or quantitative observations are made, usually by means of a standardised procedure and within a restricted period of time, but without any preconception of what the findings ought to be' (Hellawell, 1991). A crucial difference between monitoring and a survey centres about the extent to which each method is *purpose-oriented*.

Monitoring should be purpose-driven, and should aim to collect information for comparison with predefined objectives, targets or limits. Such an emphasis on the comparison of collected data with quantitative objectives forms the basis of the objective decision-making that supports evaluation. Although monitoring involves the collection of data, evaluation uses the data to interpret the effectiveness of the scheme and make decisions on the basis of evidence. In this way, the evaluation process can:

- identify the extent to which the scheme objectives are being fulfilled; and
- identify any changes that may be required to bridge the gap between policy aims and policy outcomes (Fig. 2.1).

The simple conceptual model in Fig. 2.1 reflects the guiding principles presented above. Data collected for specified indicators can be compared with targets, or baseline data; this comparison then feeds into an evaluation process. The evaluation process feeds back into the scheme and, where necessary, amendments are made to measures to improve the effectiveness of these measures. As such, the evaluation of agri-environment programmes is an iterative process that facilitates the flexibility required for continued improvement of agri-environmental schemes.

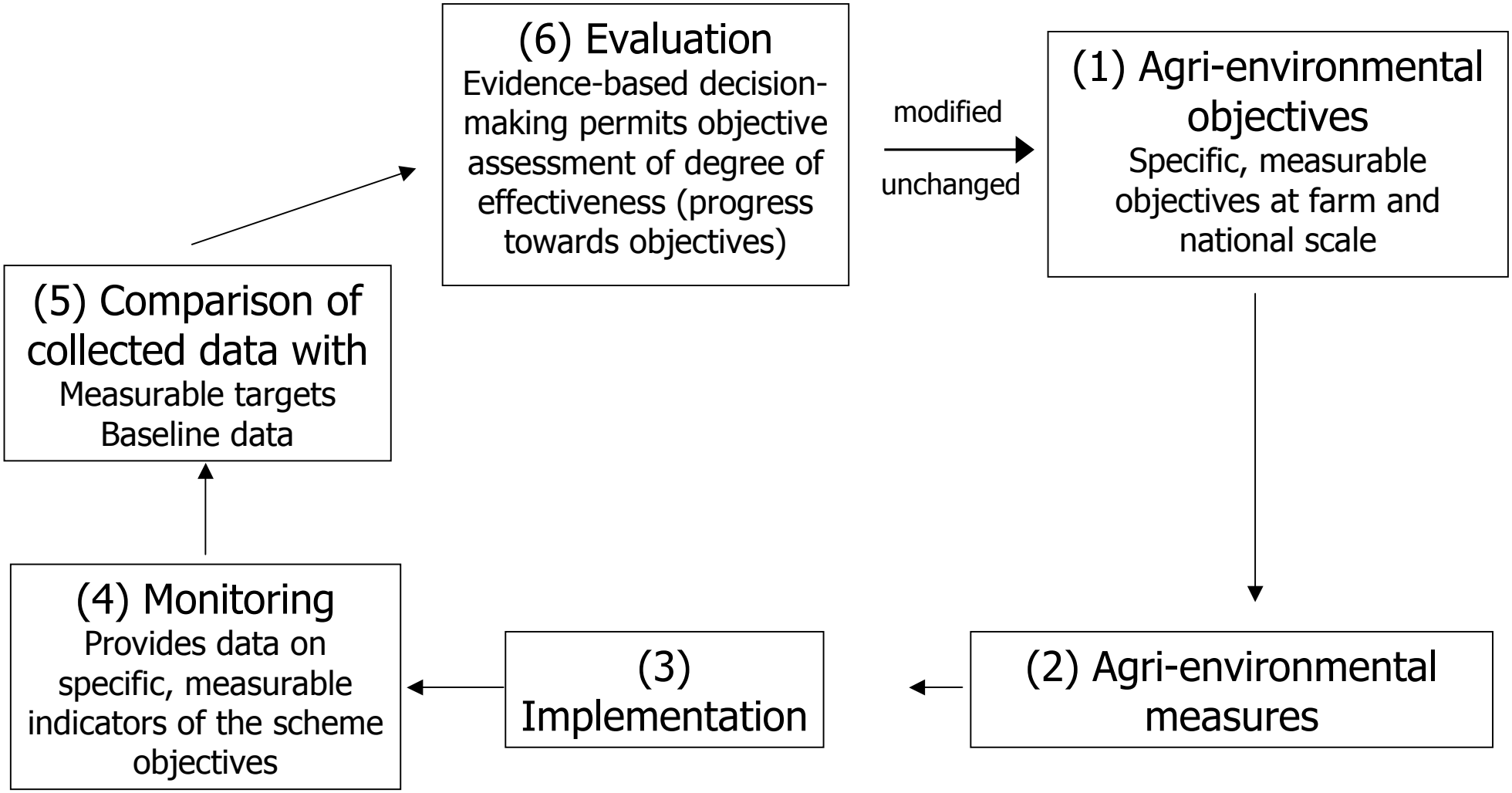

Fig. 2.1. Simple conceptual model of the contribution of a monitoring programme to an evaluation of environmental effectiveness

2.2 Indicators for agri-environmental monitoring

Agri-environmental indicators are a means of summarising and simplifying complex agri-environmental and ecological processes, and communicating information to decision-makers and the general public. Thus, indicators should provide important information about patterns or changes in the state of the environment or changes in human activity that affect the agri-environment.

A system of indicators can support policy formulation and analysis by:

- supplying decision-makers and the general public with relevant information on the state of the environment;
- supporting and informing decision-makers of the cause-and-effect relationships between farming practice / policy and the environment;
- supporting decisions to modify any initiatives, when prompted by changes in the state of the environment;
- assisting efforts to monitor and assess the effectiveness of measures to promote sustainable agriculture.

(modified from Piorr 2003)

2.3 Targets

Setting targets for the agri-environmental objectives is an important component of scheme design. The targets represent objectives to be attained, and monitoring involves the collection of data that can be compared with the targets. This comparison comprises part of the evaluation process, and facilitates a more scientific and objective measurement of 'success' or effectiveness. In devising targets, two components of the target-setting process were identified: (1) qualitative and (2) quantitative.

The devising of targets requires the formation of a statement that provides a framework with which one can determine particular levels (or a range) of values. Some examples from the existing REPS measures may be useful, as follows:

(1) The number of farms participating in the REPS by the year *X* will be *Y*.

(2) The percentage of farm area occupied by wildlife habitat on REPS farms will not be less than *X* per cent.

(3) The field margin width on REPS farms will not be less than *X* metres.

(4) Field margins will have not less than *X* plant species per m2.

(5) The stocking rate on commonages participating in the REPS will not be less than *X* livestock units or greater than *Y* livestock units.

In general, physical and chemical environmental measurements are more amenable to indicator selection and quantitative targeting. For example, the aim of improving water quality is achieved, in part, by the agri-environmental objective to ban slurry spreading from the period 1 October to 15 January (Measure 1). The indicator is 'timing of slurry spreading', the quantitative measurement is the date of slurry spreading and there is a clear reference target level for the actual slurry spreading dates to be outside the period 1 October to 15 January.

In contrast, the biodiversity aims to retain wildlife habitats (Measure 4) and maintain farm and field boundaries (Measure 5) are less specific and therefore are currently less amenable to indicator selection and quantitative targeting. It is not clear from the REPS whether and how much floral diversity is expected from the recommended level of management. In addition, there is huge spatial variation across the country, which means that wildlife issues may vary regionally or even be farm-specific (for example, where rare or endangered species of plant or animal occur).

As an example, if one looks at the possible benefits of field margin management, a bulkier sward of low plant diversity may increase the insect density and diversity on one farm. On another farm it could be more appropriate to maintain a short sward to promote greater plant species diversity. On a third farm it may be more important to fence off the margin to promote greater invertebrate and other animal diversity in the field margin by facilitating life cycle completion of plants and animals living in the margin. However, the REPS in its present form gives no indication of the objectives of Measures 4 and 5 with respect to these issues.

Setting of *qualitative* targets for indicators may also be influenced by regional or local variation in a feature under consideration within the scheme, for example:

- *Maintain* – where a feature is present and in good condition;
- *Restore* – where a feature is in poor condition and there is potential for restoration;
- *Create* – where a feature is absent;
- *None* – where a feature is absent, there is no potential for restoration, and it is not effective to create that feature.

This means that for the same indicator, targets may vary depending upon characteristics of individual farms or regions.

An objective of this study was to recommend quantitative targets for a variety of agri-environmental attributes that were identified during the study. The setting of *quantitative* values (i.e. the values of x and y in the above examples) for the qualitative statements within the current REPS was not possible within the scope of this study. This point is further discussed in Section 7.3, below.

3 Selection of agri-environmental indicators

3.1 Agri-environmental indicators: conceptual background

Environmental responses and problems are both multifaceted and complex, and environmental indicators represent a targeted method of collecting information. Many authors have examined the theoretical and practical requirements of agri-environmental indicators (Moxey *et al.* 1998, Peco *et al.* 1999, Romstad 1999, OECD 2001, Wilson and Buller 2001, Menge 2003, Piorr 2003, Primdahl *et al.* 2003).

The development of indicators tends to be based around two major factors:

(1) Quality of information: the indicator must be able to capture the state or change in state of the environment;

(2) Cost: the expected value of the information gained by the use of an indicator must be compared to the cost of collecting and analysing the data.

(from Romstad 1999)

There are a variety of desirable qualities of agri-environmental indicators. The following list is a useful summary. Within the following four categories, agri-environmental indicators should:

Scope of indicators

- inform about the status and development of complex systems;
- provide sufficient information about sustainability of land use systems;
- be responsive to changes related to human activities to indicate rapidly the success and failure of activities;
- be able to show trends over time;
- work as umbrella indicators, summarising different processes and or environmental impacts.

Policy relevance

- provide a representative picture of environmental, agricultural and rural conditions, pressures or society's response;
- be simple and easy to interpret for different users;
- provide a basis for regional, national and international comparisons;
- be either national in scope or applicable to regional issues of national significance;
- assist individual decision-makers in the private sector as well as trade and industry.

Analytically sound

- be theoretically well founded in technical and scientific terms;
- be based on international standards and international consensus about their validity;
- lend themselves to being linked to economic models, forecasting and information systems.

Measurability and data required

- be controllable;
- be readily available at a reasonable cost/benefit ratio;
- be adequately documented and of known quality;
- be updated at regular intervals in accordance with reliable procedures;
- have a threshold or reference value against which to compare them, so that users are able to assess the significance.

(from Piorr 2003)

European agri-environment policy also advises on qualities of indicators that should measure performance for agri-environmental programmes. Such agri-environmental indicators should be:

- easily collected or sufficiently important to justify the difficulties involved;
- able to cover the entire programme as well as measures within it;
- closely related to the objectives established;
- useful to the implementing agencies;
- reliable and consistent from one time period to another;
- clearly defined and consistently interpreted;
- collected on a sufficiently regular basis to allow their use as evaluation tools.

(European Commission 2000)

The main limitations associated with the use of agri-environmental indicators are

(1) a lack of linearity;

(2) time lags between implementation and observed improvements in performance;

(3) unequivocal causality in the response of environmental parameters to specific pressures.

(Peco *et al.* 1999).

For example, there may be threshold levels, rather than linear gradients, beyond which environmental problems appear (linearity); there may be time lags between the implementation of initiatives and the detection of positive environmental responses (immediacy). In addition, multiple factors may potentially cause some particular environmental problem; therefore, it can be difficult to be certain that a management prescription is targeted at the specific cause (equivocal causality).

Other potential limitations associated with the identification of indicators in large-scale monitoring programmes include the following:

- Lack of thresholds, basis figures or reference levels, so that often no orientation is given whether trends in the environmental development are strong or weak, e.g. as for biodiversity.

- Spatial relation is not sufficiently considered. On the international scale, the use of average values on the country level is widespread so that regional environmental loads are neglected.

- Lack of priority-setting of indicators so that a ranking of strategies for the enhancement of sustainable land use of agricultural landscapes is not yet possible on the basis of agri-environmental indicators.

- Long-term monitoring programmes are necessary to realise long-term environmental changes.

- Indicator development is dominated by measurable parameters, which distracts from those impacts dealing with non-quantifiable values such as aesthetic, ethical or cultural values.

- Application of models without realising their limits and deficits because of a lack of information.

- Different availability of data and information on the national and international level.

(From Piorr 2003)

Despite the caveats, indicators are still widely viewed as an essential and effective tool in the assessment of the impact of agri-environment schemes. The potential for these difficulties places a considerable onus on the selection of appropriate and relevant indicators. Ultimately, the selection of appropriate indicators is a trade-off against what is 'feasible, affordable and manageable' (Wilson and Buller 2001).

3.2 Criteria used for development and evaluation of indicators in this study

A comprehensive (though not exhaustive) list of possible agri-environment indicators in the categories of landscape, biodiversity and agronomy is presented in Appendices

1–3. The list of agri-environmental indicators may contain examples that are not appropriate to the current REPS; however, such a list is intended to provide a source of indicators that may be appropriate if the REPS was changed in the future.

All indicators were evaluated for their suitability for use in monitoring the REPS in terms of the following criteria:

- **Relevance/importance –** as reflected by the degree to which the indicator corresponds to the stated aims of the REPS. 1 = minimum relevance. 5 = high relevance.

- **Reliability/validity –** refers to the expectation of a real environmental output from the proposed change in management; typically based on the scientific literature and established practice elsewhere. 1 = low reliability, i.e. there is little evidence to support the expectation of an environmental output. 5 = high reliability, i.e. strong justification for an expected environmental improvement.

- **Responsiveness –** reflects the expected time lag between a change in management and a measurable change in the environment.1 = low responsiveness, i.e. the magnitude of environmental output is relatively low and/or there is negligible environmental output within a period of five years. 5 = high responsiveness, i.e. the magnitude of environmental output is relatively high and/or there is an observable environmental output within a period of one to two years.

- **Logistical feasibility/effort of sampling –** refers to the ease with which the information or data on the indicator can be collected or measured. 1 = low feasibility, i.e. the collection of data / environmental measurements is difficult or unfeasible. 5 = high feasibility, i.e. the collection of data / environmental measurements is highly feasible.

- **Cost –** refers to the cost–benefit ratio of the indicator (related to logistical feasibility above). 1 = high cost, i.e. the cost of implementing the indicator is too high in relation to the information gained. 5 = low cost, i.e. the cost of implementing the indicator is low in relation to the information gained.

- **Data availability –** reflects the degree to which data on the indicator already exist in national databases. 1 = no data currently available. 3 = data available but not in a suitable format, or the quality of the data makes them unsuitable for use. 5 = data available and suitable for use in the indicator process.

A summary of selection criteria and interpretation of values in indicator tables is shown in Table 3.1.

Table 3.1. Criteria used in the development of agri-environmental indicators, and the interpretation of values.

Selection criteria	**1**	**2**	**3**	**4**	**5**
Relevance	very low	low	moderate	high	very high
Reliability	very low	low	moderate	high	very high
Responsiveness	very low	low	moderate	high	very high
Logistical feasibility	very low	low	moderate	high	very high
Cost	very high	high	moderate	low	very low
Data availability	none		unsuitable		suitable

Box 3.1 shows a worked example of an indicator, which should aid interpretation of the indicator tables.

Box 3.1. Hedgerow data: an example of an agri-environmental indicator.

Indicator: Hedgerow length per unit area

Hedgerows and linear features are regularly proposed as agri-environmental indicators. The amount of hedgerow can be measured as the length of hedge in metres or kilometres per hectare, or per hectare of utilised agricultural area (UAA). The Department of Agriculture, Food and Rural Development (1999) includes the mean length of hedgerow per REPS farm as one of its indicators in the REPS mid-term review.

***Relevance/Importance**:* A number of the REPS measures are concerned with the maintenance and management of hedgerows and field margins (uncultivated strip alongside the hedgerow). They are as follows:

Measure 4 Retain wildlife habitats.
Measure 5 Maintain farm and field boundaries.
Measure 6 Cease using herbicides, pesticides and fertilisers in and around hedgerows, ponds and streams.
Measure 9 Produce tillage crops without burning straw/stubble and leaving field margins uncultivated. **Score: 5**

***Reliability/Validity**:* There is considerable evidence to support the value of hedgerows as habitats and wildlife corridors. **Score: 5**
(Note that the amount of hedgerow present says nothing of the quality *of the hedgerow in terms of size, structure or botanical composition. Additional, more specific indicators are required to measure hedgerow quality*).

***Responsiveness**:* This indicator can provide immediate measurement of any changes in hedgerow length. **Score: 5**

***Logistical feasibility**:* The logistical effort involved in collecting data on the amount of hedgerow is relatively low. **Score: 5**

***Cost**:* The cost of recording this variable as an agri-environmental indicator is low as the data are already available for REPS farms. **Score: 5**

***Data availability**:* The length of hedgerow per REPS farm has been calculated by REPS planners. Each REPS plan includes the length of both boundary and internal hedgerow. **Score: 5**

Comments

The variable 'hedgerow length per unit area' is a useful agri-environmental indicator in terms of its relevance to the REPS. The amount of hedgerow is an indicator of habitat diversity and the extent of semi-natural habitat present in the farmed landscape. However, more specific indicators of hedgerow *quality* are probably required to complement this agri-environmental indicator.

There is a degree of subjectivity in the scoring of variables according to the above criteria. However, the criteria represent a rational basis for the decisions of inclusion. Note that we did not necessarily score each of the indicators along all of the selection criteria. Generally, the selection criteria were used to indicate the criterion that was most important in including or excluding a particular attribute from the table of indicators that are appropriate to the REPS.

3.3 Tiered approach to indicator selection

There is an extensive range of potential indicators of agri-environmental schemes, some of which are more general than others. Therefore, the three categories of landscape, biodiversity and agronomy were each subdivided into three tiers of indicators (basic, moderate and advanced). Broadly speaking, the basic, moderate and advanced tiers correspond to differences in the rigour, quality or requirements of the following issues:

- data availability;
- expertise required;
- logistical effort;
- quality of information ;
- validity of causal mechanisms.

Indicative characteristics of the three tiers are as follows:

3.3.1 Basic tier

- Data available or easily collectable (through REPS plans, REPS 5V form, Central Statistics Office, National Farm Survey, etc.).
- Does not require high level of expertise to monitor.
- Straightforward to implement (easy to obtain).
- Data could be collected from each participating farm.

- However, does not provide high-quality data on the performance of a scheme (low validity).

3.3.2 Moderate tier (to complement and add to data from basic tier)

- Data may or may not be available, but are easily collectable.
- A moderate level of expertise required (general environmental scientist, ecologist, planner with environmental training).
- Data could be collected from a high proportion of participating farms (and control farms).
- Provides medium- to high-quality data on the performance of a scheme (medium validity).

3.3.3 Advanced tier (to complement and add to data from basic and moderate tiers)

- Data not available for each farm.
- A moderate to high level of expertise required for sampling and monitoring.
- Involvement of universities recommended at this level, thus incorporating scientific research in addition to monitoring.
- Data to be collected from a sample of participating farms (and control farms).
- Provides high-quality data on the performance of specific objectives of a scheme (high validity).

4 Landscape indicators

This section proposes indicators that could be employed to examine the environmental effectiveness of the REPS in maintaining and improving characteristics of the Irish landscape. A precise definition of 'landscape' is difficult. The Oxford English Dictionary defines landscape as *all the visible features of an area of land*. However, for many people, 'landscape' encompasses more than the visual geomorphological features and includes the complex interactions between human societies and the natural environment.

A comprehensive compilation of landscape indicators for agriculture and agri-environment schemes sourced from literature and other agri-environment scheme monitoring programmes is shown in Appendix 1. The first section of the table contains general landscape indicators. Target values are presented where appropriate.

The data in the Appendix have been refined and grouped on a tiered basis as described earlier.

4.1 Landscape indicators: basic tier

Landscape indicators (basic tier)	Measurement	Comment
Number of REPS farms per unit area	Number of REPS farms per defined area	
Number of REPS farms participating in supplementary measures	Supplementary Measure A Long-term set-aside Organic farming	
Intensity of land use	Area of tillage per UAA Number of crops per arable area Number of crops per rotation Area of permanent grassland per UAA	
Forestry on REPS farms	Area of land under forestry Afforestation rate	
Features of archaeological and/or historical interest	Number of features to be retained Type of feature Average number of features per farm on sites and monuments register (SMR) Average number of new features per farm not previously recorded on SMR	
Presence/occurrence of traditional farm buildings, listed buildings	Number of traditional farm buildings for retention / renovation	
Farmyard screening	Proportion of the farmyard given to shelter/tree cover	
Management of heritage features	Proportion of farmers that practise active management of heritage features, e.g. fencing off, restoration, allow grazing	

4.2 Landscape indicators: moderate tier

To complement and add to basic tier data

Landscape indicators (moderate tier)	Measurement	Comment
Diversity of wildlife habitats	Number of farms with e.g. >3 or >6 habitats Number of farms with minimum of 3–6% of area occupied by natural/semi-natural habitat Number of farms with >15% habitat Habitat removal (ha) Habitat creation (ha) Net change (ha)	A monitoring programme would need a clearly defined list of the relative conservation value of the different habitats found on farmland Habitat diversity indices
Tree cover (commercial) **Plantations on REPS farms**	Previous land use Mostly conifer Deciduous/conifer Mostly deciduous	
Tree cover (non-commercial) **Woodland on REPS farms**	Mostly conifer Deciduous/conifer Mostly deciduous	
Litter/farm refuse management **Plastic recycling (fertiliser bags, silage wrapper)**	Recycling and farm waste collection	
Farmyard wildlife **Provision for nesting birds, bats and other wildlife in farm buildings**	Proportion of farm buildings with nesting Barn Owl Swallow House Martin Bats Other species	Features in the farmyard can be made wildlife-friendly Other species can be identified using Biodiversity Action Plans in the future

4.3 Landscape indicators: advanced tier

To complement and add to basic and moderate tier data

Landscape indicators (advanced tier)	**Measurement**	**Comment**
Habitat distribution	Habitat inventories and vegetation maps	Dependent on data availability, e.g. remote sensing
Linkage among wildlife habitats	Presence of wildlife corridors	Connectivity indices Fragmentation indices
Connectivity of grasslands		Connectivity indices
Mean patch/field size (of agricultural parcels)		
Length and distribution of different edges		
Length of hedgerow pre-dating AD 1700		

5 Biodiversity indicators: protection of wildlife habitats and endangered species of flora and fauna

This section of the document is concerned with identifying indicators suitable for measuring the impact of the REPS on wildlife habitats, flora and fauna. Indicators that could be employed to monitor the impact of the REPS on these aspects of the farming landscape are presented.

A comprehensive compilation of biodiversity indicators for agriculture and agri-environment schemes sourced from literature and other agri-environment scheme monitoring programmes can be seen in Appendix 2. The first section of this table contains general indicators for genetic, species and habitat diversity; it includes some indicators that are already used by the Department of Agriculture and Food. These indicators reflect the more general objectives within Measures 4, 5 and 6 to maintain and protect wildlife.

Appendix 2 lists specific indicators that collect sufficiently detailed information to assess the quantity and quality of farmland habitats and some of the species reliant on these areas. These indicators are most appropriate for monitoring the conservation value of a selected habitat (habitat quality, as opposed to quantity), and are also most appropriate for monitoring the conservation value of those habitats covered by Supplementary Measure A. Target values are presented where appropriate.

5.1 Biodiversity indicators: basic tier

Biodiversity indicators (basic tier)	Measurement	Comment
Genetic diversity: preservation of rare domestic breeds	Number of participants in rare breeds supplementary measure The number of registered females of listed rare breeds	
Areas of Natural Heritage and Special Areas of Conservation covered by REPS	Number of participants in Measure A Area of different categories of designated areas managed under the REPS	
Habitat audit: availability of wildlife habitat on farmland (outside targeted areas)	Number of habitats Types of habitat Percentage cover of habitats on farmland	A monitoring programme would need a clearly defined list of the relative conservation value of the different habitats found on farmland.
Level of management recommended for each habitat	Retention/maintenance/ improvement/ enhancement	
Length of hedgerows and stone walls	Length of hedgerows and stone walls (m) per UAA/ha	
Area of cereal margins under environmental management	Area of cereal margins under REPS management	
Length of watercourse receiving maintenance	Length of watercourse (m) under management (including fencing)	

5.2 Biodiversity indicators: moderate tier

To complement and add to basic tier data

Biodiversity indicators (moderate tier)	Measurement	Comment
Area of semi-natural grassland	Define grassland type according to Fossitt (2000) Grassland area (ha)	
Diversity of wildlife species	Number of species present Presence/absence of particular species Conservation status of species present	A list of wildlife species of conservation concern would need to be identified. Examples might include orchids, bats, frogs, etc.
Management of areas for breeding waders and waterfowl	Size of area Number of species of waterfowl Estimated population sizes Timing of mechanical operations Timing of grazing/mowing Application of fertilisers Application of slurry	This example demonstrates how monitoring can be targeted towards a particular wildlife group. Such monitoring could be applied to other selected groups.
Botanical diversity of field margins	Botanical diversity of field margins Botanical diversity of grassland Diversity of non-cultivated plants / rare arable weeds	A simplified scoring system could be devised, e.g. >5 species or plant groups , >10 etc.
Hedgerow quality	Length, height, width (<1m, 1–2m, >2m) Density (length or volume of hedge per hectare) Management regime Number of mature trees Diversity of tree species Diversity of plant species Gappiness	
Watercourses (channels that usually convey water for 9 months) and drains (which do not convey water for this period)	Width Height of bank Depth of water Slope of sides Number of aquatic plant species Proportion of area covered by aquatic plant species	

	Emergent vegetation present Width of buffer strip between water course and agriculturally managed area Frequency and timing of key management practices	

5.3 Biodiversity indicators: advanced tier

To complement and add to basic and moderate tier data

Biodiversity indicators (advanced tier)	Measurement	Comment
Threatened species	Trends in distribution and abundance of threatened species of fauna dependent on agricultural practices Trends in threatened species of flora dependent on agricultural practices	Would require trained biologist/zoologist.
Botanical diversity	Botanical diversity of field margins Botanical diversity of grassland Diversity of non-cultivated plants/rare arable weeds Proportion of competitor, stress-tolerator and ruderal species	More detailed survey than moderate tier. Would require trained botanist.
Habitat quality	For example, depending on habitat: Number of plant species per unit area Dominant species Proportion of competitor, stress-tolerator and ruderal species (CSR) Proportion of grass species Proportion of broadleaved plant species Proportion of bare ground Presence of desirable plant species, e.g. tussock-forming species and those attractive to invertebrates Height of sward in mid-summer Absence of pernicious weeds Time since last ploughed Time since last mown Time since last grazed Time since last application of slurry or fertiliser Time since last application of herbicide	This would be a method of assessing the quality and conservation value of specific habitats. The presence of rare species associated with those habitats under investigation is a key indicator of its quality. Would require a trained ecologist.
Invertebrate diversity	Sampled in crop/grassland and field margins/hedgerows Pollinators such as butterflies and moths, bees and hoverflies Other potential indicator groups include carabid beetles, spiders, parasitoid wasps, collembola, staphylinid beetles and others	Insect groups are frequently used as indicators of wider wildlife diversity. Would require trained entomologist/zoologist.

6 Agronomic indicators

A comprehensive list of agronomic indicators is provided in Appendix 3. Selected indicators from Appendix 3 were grouped on a tiered basis.

6.1 Agronomic indicators: basic tier

Agronomic indicators (basic tier)	Measurement	Comment
N fertiliser	Change in use of N fertiliser at farm-scale since joining the REPS	
	Inorganic N fertiliser sales	(Regional rather than farm-scale)
	Changes in stocking rate (contribution of organic N)	Reduction in livestock units per UAA since participating in the REPS
	Total N use on REPS farm (organic and mineral) Number of cuts of silage	
P fertiliser	Change in use of P fertiliser at farm-scale since joining the REPS	
	Inorganic P fertiliser sales	(Regional rather than farm-scale)
	Stocking rate (contribution of organic P) Soil tests for phosphorus levels Change in phosphorus index over time on REPS farms Proportion of soils on REPS farms at different phosphorus levels	
Soil management	Timing of inorganic fertiliser application Soil pH Lime use	
Organic manures	Months of available slurry storage on the farm Storage method for slurry Storage method and management of farmyard manures (area covered) Integration of organic manures into nutrient management plan Amount of manure/slurry spread on land Timing of organic nutrient/manure applications	
	Location of organic nutrient/manure application	This assesses uniformity of spreading across fields

Water management	Presence/absence of system to separate clean and dirty water Area of long-term set-aside	
Silage storage	(Including silage effluent management)	
Stocking rate	Reduction in livestock units per UAA on REPS farms Rough grazing/uplands livestock units per grassland and fodder crops area	
Farmyard investment in nutrient management	Amount of capital investment in farm facilities Number and value of Control of Farmyard Pollution Grants awarded	

6.2 Agronomic indicators: moderate tier

To complement and add to basic tier data

Agronomic indicators (moderate tier)	Measurement	Comment
Nutrient management	Nutrient balance N (farm gate) Nutrient balance P (farm gate)	
	Methods used to prevent fertiliser being spread into hedgerows and water courses	Machinery adjustments. Distance of tramlines from hedgerow/waterbody (tillage areas)
	Nitrate losses from agriculture to freshwater in selected catchments	e.g. ranking scheme for risk of nitrogen loss/transport (Magette 1998)
	Phosphorus loss	e.g. phosphorus losses from agriculture to freshwater in selected catchments e.g. ranking scheme for risk of phosphorus loss/transport (see Magette 1998)
Pesticide use	Intensity of use of pesticides, e.g. pesticide type, volume used, toxicity Application methods to prevent drift of spray	
Riparian zones	Length/proportion of water course fenced off Width and length of riparian vegetation adjacent to watercourse (intercept groundwater discharge)	

6.3 Agronomic indicators: advanced tier

To complement and add to basic and moderate tier data

Agronomic indicators (advanced tier)	Measurement	Comment
Nutrient management	Clover cover (contribution of clover to N supply) Autumn soil testing for residual N C : N ratio of organic nutrient/manure	
Water quality and watercourse management	Chemical analysis of water quality Biological index of on-farm streams Condition of receiving waters (groundwater and surface water)	It is extremely difficult to relate these indicators to REPS practices. Such direct measures of water quality are confounded by many variables. National-scale data on water quality is available from River Basin Districts and the EPA.
	Water quality of farm wells Presence of pathogens and nitrates in farm wells	Trained technician required to collect these data

7 Discussion and conclusions

7.1 Interpretation of monitoring data and scheme evaluation

A number of studies have advanced the conceptual development of the contribution of monitoring data to the evaluation of agri-environmental policy (including agri-environmental schemes) (e.g. Goldsmith 1991, Hellawell 1991, Countryside Council for Wales 1996, Lee and Bradshaw 1998, Noss 1999, Duelli and Obrist 2003, Kleijn and Sutherland 2003, Primdahl *et al*. 2003). A conceptual model of how monitoring data facilitate the evaluation of agri-environmental policy is demonstrated in Fig. 7.1. Notably, the flow diagram is dependent on the initial specifications of the objectives of an agri-environmental programme. Such specifications would include the nomination of specific, quantitative environmental improvements that are required of the scheme and the management practices required to achieve these objectives (these correspond to particular Measures). The selection of appropriate indicators may best be conducted at this stage also.

Monitoring is conducted to investigate whether these objectives are being addressed. Simply put, the information that is collected from the monitoring exercise can be compared with the original, expected environmental improvements (see below). Such a comparison facilitates objective decision-making about the effectiveness of the scheme.

In instances where there appears to be no benefit from participation (a Measure is ineffective), two main possibilities arise (assuming that the indicator is appropriate and not confounded by time lags and similar issues). Firstly, there is low compliance and the recommended management practices are not being implemented (compliance inspections may indicate the likelihood of this possibility). Secondly, the recommended management practices *are* being implemented, but these practices are not sufficient to achieve the desired environmental objective. In the latter case, this would point to the need to modify the specifications of the Measure.

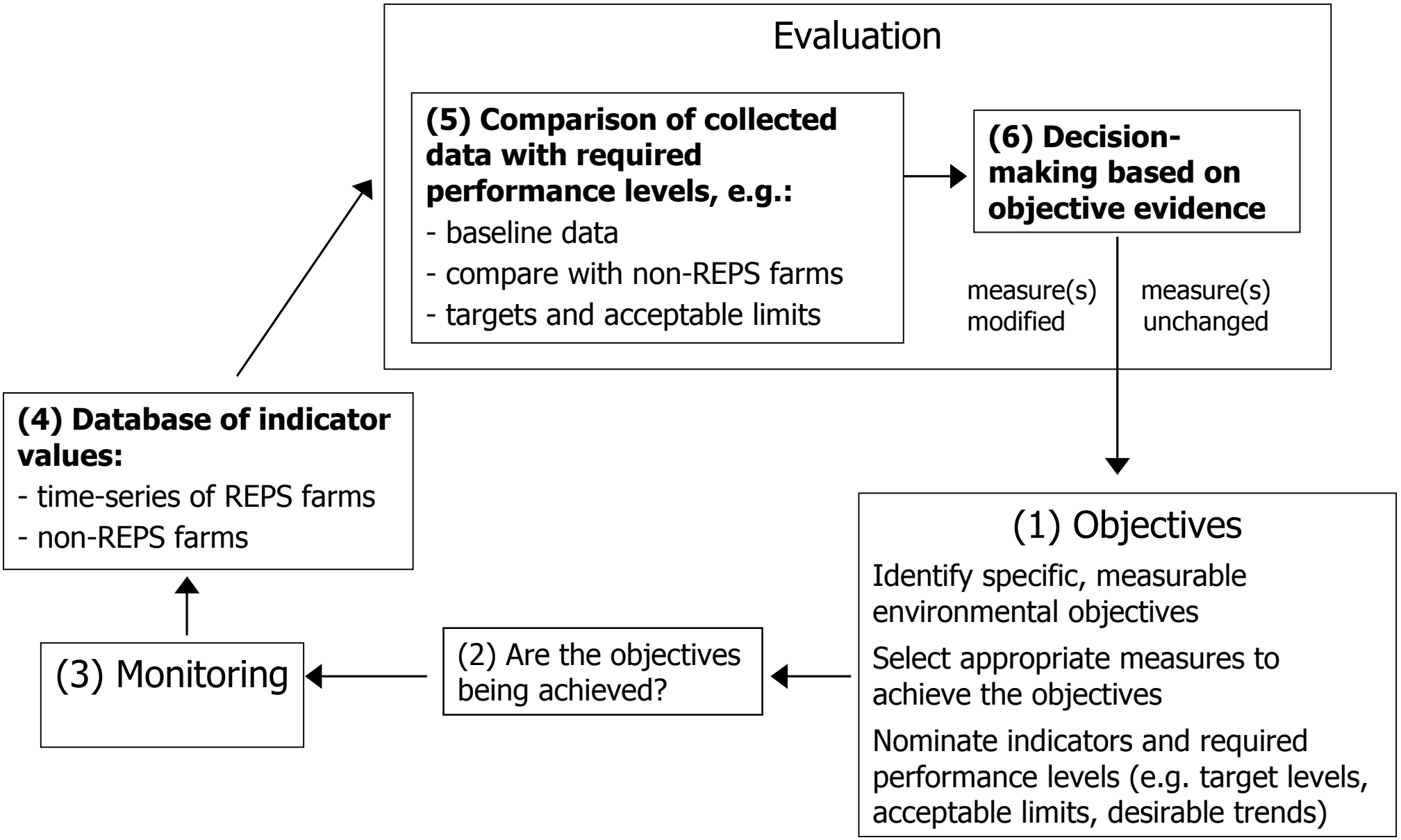

Fig. 7.1. Flow diagram of the inter-relationship among scheme objectives, monitoring, indicators and scheme evaluation

The evaluation model proposed in Fig. 7.1 is crucially dependent on a number of possible comparisons with collected data (see Fig. 7.2). The collected data may be compared with:

(1) **Baseline data.** The comparison of current and previously collected data permits an objective, quantitative comparison of changes in an agri-environmental indicator over time (e.g. Fig. 7.2A).

(2) **Data from non-REPS farms.** One would expect an environmental benefit on REPS farms that is over and above that observed on non-REPS farms. Over time one could detect (and expect) emerging trends that demonstrate the added value of the REPS (for example, compare Figs. 7.2B and 7.2C). Note that there are very important statistical issues to be addressed when selecting farms and conducting comparisons of REPS and non-REPS farms: care is needed in interpreting such data. Simply put, REPS and non-REPS farms are composed of many different farming systems. In addition, REPS and non-REPS farms are not random subsamples of Irish farms: certain farming systems and farm types are far more likely to join the REPS than others. Environmental comparisons of REPS and non-REPS farms may (but not necessarily) confirm selective participation of farm types, rather than demonstrate the benefits of scheme participation (see Carey *et al*. 2002).

(3) **Target levels.** Initially, observed data may be used to confirm that farm practices are attaining levels set out in Good Farming Practice, as required by agri-environment schemes. Additionally, the observed data may be used to compare the observed data with specific, measurable, target levels that exceed good farming practice and that REPS participants are required to attain (e.g. Fig. 7.2D).

In practice, a combination of all three of the above options may be necessary and acceptable. For example, the potential problems in the comparison of agri-environmental data from REPS and non-REPS farms can be overcome by the measurement over a period of time, which may demonstrate benefits of scheme participation (e.g. Fig. 7.2B). In practice, particular combinations of the above approaches are more appropriate for some indicators than for others.

As an example, the following data provide a REPS versus non-REPS comparison, and a comparison with baseline data; the combination of approaches makes a more persuasive argument for the effectiveness of the scheme. Thus, between 1994 and 1997 average fertiliser application rates on REPS farms decreased from 70 to 61 kg nitrogen per hectare and from 13 to 10 kg phosphorus per hectare: on extensive non-REPS farms in the same period, average fertiliser application rates decreased from 98 to 85 kg nitrogen per hectare and from 16 to 14 kg phosphorus per hectare (Department of Agriculture, Food and Rural Development 1999).

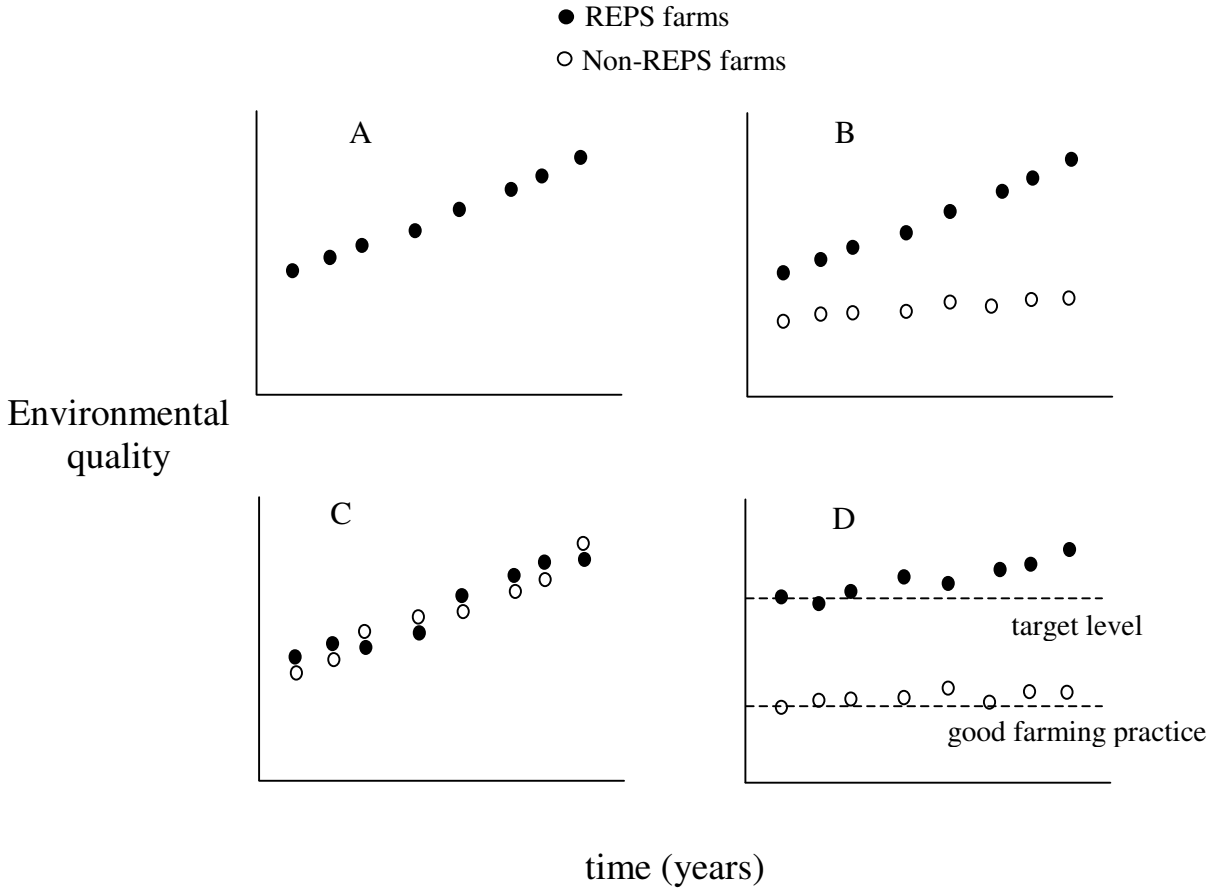

Fig. 7.2. Illustration of the use of monitoring data (for an indicator) to support scheme evaluation and demonstration of environmental effectiveness. Monitoring data can deliver an objective demonstration of improvements over time (A). This information is best accompanied by data from non-participating farms (B), to prove a benefit over and beyond what may have happened anyway (e.g. scenario in C). Data from monitoring can also be compared with specified and quantitative environmental requirements (D).

7.2 Indicator selection is dependent on specific objectives

The difficulties in setting quantitative targets for many of the agri-environmental indicators were acknowledged by the Project Group, experts and stakeholders groups during the project. Indeed, the original project proposal highlighted the potential difficulty in describing quantitative targets.

In hindsight, it is apparent that the construction of a measurable indicator and a quantitative target level is crucially dependent on the presence of specific, measurable objectives. Therefore, the construction of a measurable indicator and a quantitative target level will be confounded if the agri-environmental objectives are not sufficiently specific or measurable. In effect, it will be difficult to propose an indicator and interpret the data if there is ambiguity about the desired environmental state that is to be 'indicated'. It is reasonable to expect that some objectives and measures have more generality than others; correspondingly, some indicators have more generality than others. However, it would be useful to have greater clarity about which objectives and measures are intended to be broadly applicable in a general context, and which objectives are intended to achieve more specific agri-environmental improvements.

Unfortunately, this study made relatively little progress in suggesting target values. Despite specific requests, most stakeholders and experts did not comment at the level of detail required to provide quantitative targets. This was probably for a number of reasons. Most likely, however, is that neither the Project Group nor the experts and stakeholders had a sufficiently clear understanding of the specific and measurable environmental objectives of the REPS. Therefore, the task of setting quantitative targets not only required the setting of targets, but also required a detailed description of the environmental objectives of the scheme. Although a potentially very useful exercise, this would be a much bigger undertaking than was possible during this project, and was not an original objective.

Nevertheless, our investigation of different uses of monitoring in environmental evaluation suggests that other approaches are available (see Figs. 7.1 and 7.2) that are not so dependent on the specification of quantitative targets, although this is desirable (see above).

7.3 Implementation of a monitoring programme: the tiered approach

This study proposes a tiered approach to the implementation of a monitoring programme for the REPS. The three tiers reflect the different resource demands and quality of information provided by a monitoring programme. The 'basic' tier corresponds to indicators that may already be collected, or are potentially easily collected, whereas the 'advanced' tier corresponds to those indicators for which new monitoring by experts will be required. This approach was decided upon as a result of expert consultation and was also suggested in a recent comprehensive review of biodiversity agri-environmental indicators (Büchs 2003).

Following the development and selection of a core set of indicators (which would be applicable across different farming systems in different regions), one could identify relevant data collected from existing data-collection exercises (e.g. National Farm Business Survey and National Farm Facilities Survey, existing REPS plans, research projects, etc.). There may be a considerable logistical effort (and therefore cost) required to implement an adequate level of monitoring to collect data that correspond to the selected indicators. Many of these data listed in the basic tiers have been used in previous evaluations of the REPS. There is also a possibility of incorporating data from other existing farm surveys, and adding extra questions to such surveys in the future.

We recommend that additional indicators from the moderate and advanced tiers be used to augment the basic-tier data. To achieve this, however, it is necessary to further clarify and specify some of the current aims of the REPS and its agri-environmental objectives. Clarity in the objectives is a precursor to implementation, monitoring and evaluation. Such clarification is necessary before appropriate indicators and targets (at regional and national level) can be identified.

The agri-environmental objectives of the REPS seek to cover a broad spectrum of agri-environmental concerns:

- The conservation of landscape, and endangered species of flora and fauna;
- The addressing of 'wider environmental problems';
- The fostering of environmentally friendly methods of food production.

The specific landscape features to be protected need to be quantified. The endangered species of flora and fauna to be conserved need to be clearly identified, including the necessary processes with which to achieve this objective. Defining what is meant by 'environmentally friendly farming' is very subjective and open to a variety of interpretation.

Another benefit is that greater clarity of objectives will clarify the expectations of stakeholders. While such clarification may increase the level of expectation that the stated objectives will be attained, it would also have the distinct advantage of reducing unrealistic levels of expectation.

7.4 Implications for scheme design

Whilst this document focuses on monitoring, the first important step is that the recommended management practices (the actions) are appropriately implemented. Monitoring is the tool with which to measure the effectiveness of actions. The evaluation process identifies any needs for improvement that inevitably arise, and decides on the best course of action for more effective achievement of the objectives. As demonstrated in Figs. 2.1 and 7.1, there are clear linkages among the processes of scheme design, monitoring and evaluation.

Towards maximising such linkages and achieving the clarity mentioned in the previous section, we recommend as best practice a consideration of the needs of a monitoring programme *at the design stage* of a scheme (whether this is the initial design of a scheme or the design of modifications to a scheme). This contrasts with a consideration of the needs of a monitoring programme as a bolt-on activity that occurs after (or separate to) the design of a scheme.

Thus, when future modifications of the REPS are being designed, the template shown in Box 7.1 may assist in achieving greater integration across all the aims of scheme design, implementation, monitoring and evaluation. This proposed template reflects an implementation of the evaluation process described in Figs. 2.1 and 7.1, which is based on the maxim 'If you can't measure it then you can't manage it.'

Box 7.1. Suggested template for integrating scheme design, implementation, monitoring and evaluation.

(1) What environmental issue is being addressed by a Measure?

(2) What are the objectives of a Measure?

(3) What are the specific agri-environmental objectives and targets?

(4) What management practices would be expected to achieve these objectives?

(5) What effects are such management practices expected to produce?

(6) In what timeframe will such effects become apparent, and the objectives be achieved?

(7) In what farm situations would a Measure and its management practices be expected to be most appropriate?

(8) In what farm situations would a Measure and its management practices be expected to be least appropriate or not appropriate at all?

(9) What research supports the validity and appropriateness of these management practices?

(10) What indicators would measure the achievement of these objectives?

(11) How would the data on the indicators be best collected?

(12) How would the indicator data be analysed to conclusively demonstrate that the objectives are, or are not, being attained?

(13) If the data indicate that the objectives are not being attained, then what modifications to the Measure, its management practices and/or its objectives are likely to be required?

7.5 Overview of the implementation of a monitoring scheme

During consultations with stakeholders, there were different interpretations of how a monitoring scheme might be implemented. During the course of the project, when requested, we explained our understanding and expectations of a monitoring programme to some (though not all) of the stakeholders. Indeed, several stakeholders requested information on this issue in their submissions. For clarity, this is briefly described, as follows:

Effective monitoring is not a stand-alone activity and should form part of an integrated process. For example, the aims of agri-environmental schemes to improve facets of environmental quality need to be translated into specific, unambiguous and measurable objectives. Once the objectives are decided upon, management practices should be implemented that should achieve the objectives. Monitoring is intended to measure what progress is being made toward the objectives. Thus, monitoring has an important input to the evaluation process, which aims to identify the extent to which policy objectives are being fulfilled, and identify any changes that are required to bridge the gap between policy aims and policy outcomes. As such, the evaluation of agri-environment programmes is an iterative process that facilitates the flexibility for improvement of agri-environmental schemes (from Finn 2003).

Although there is a certain element of speculation about the detail, our broad vision of the implementation of a monitoring programme is as follows. In practice, we envisage that monitoring will be conducted by an independent team of environmental scientists with expertise in, for example, water quality, ecology, agricultural management. This team may require four to ten persons, depending on several factors. This team would visit a proportion of farms participating in the REPS, as well as some farms not participating in the REPS. The team would inform a farmer that they wish to visit the farm, and would spend several hours taking various measurements, talking with the farmer, etc. The measurements collected would correspond to the agri-environmental indicators for the scheme. The independent team of specialists would be responsible for the collection, analysis and interpretation of the data.

Monitoring of the environmental effectiveness of the scheme should not be confused with inspections of compliance. Environmental monitoring would examine the effectiveness of the scheme and its measures in delivering environmental benefits. The source of the data should remain anonymous, and there would be no repercussions for individuals whose performance is below what might be expected. This is in contrast to inspections of compliance with REPS measures, which falls under the remit of the Department of Agriculture and Food, and penalises individual farmers for non-compliance.

7.6 Experimental design and logistics

Relatively few environmental monitoring programmes have been established for agri-environmental schemes, and there are even fewer published results. Of the 26 European countries that implement agri-environmental schemes, a comprehensive review identified 62 studies from five EU countries and Switzerland that investigated the impacts of schemes on biodiversity (Kleijn and Sutherland 2003). With the possible exception of the UK and the Netherlands, that study identified 'a lack of research examining whether agri-environment schemes are effective'. The authors commented that 'In the majority of studies, the research design was inadequate to assess reliably the effectiveness of schemes ... The lack of robust evaluation studies does not allow a general judgement of the effectiveness of European agri-environment schemes.' Thus, many studies were not able to address their objective of investigating the effectiveness of biodiversity schemes (despite the logistical effort and financial resources invested in the studies). Kleijn and Sutherland's findings are a salutary lesson of the need for careful planning and appropriate expertise when designing monitoring studies.

To be effective, monitoring requires a thorough planning of the objectives of the monitoring programme, the experimental design, data sampling methods, data analysis and data interpretation. Only when all of these elements are satisfactory can monitoring reliably and usefully inform evaluation.

The logistical effort required to achieve an adequate level of monitoring can be considerable, and reinforces the importance of a carefully planned monitoring programme to ensure effectiveness and value for money. Carey *et al*. (2002) surveyed

a range of wildlife indicators across 451 sites in England (and 49 additional sites where boundary features only were surveyed); Kleijn *et al*. (2001) surveyed wading birds in 78 fields in the Netherlands; Feehan *et al*. (2002b) surveyed field margins on 60 farms in Ireland. It is also worth remembering that these surveys were concerned with wildlife only; other surveys may be necessary for other agri-environmental objectives, e.g. water quality, soil condition, soil fertility, agro-chemical applications, landscape character etc. Each of these issues may well require significant subject-specific expertise in design, execution and analysis (modified from Finn 2003).

Another recent study conducted interviews with 789 farmers participating in agri-environmental schemes across 22 case-study areas in nine EU member states and Switzerland and with 211 non-participating farmers (Primdahl *et al*. 2003). Based on 12 agri-environmental indicators, farmers were questioned on their farming practices. Compared to non-participant farmers, participating farmers undertook more agri-environmental activities that would be expected to maintain or improve environmental quality (although it is difficult to quantitatively interpret the exact magnitudes of the environmental effects). Nevertheless, the study identified indicators that were being commonly used across a variety of schemes and demonstrated clear and convincing evidence that agri-environmental policies had influenced the management practices of farmers in ways that would clearly *be expected* to have positive environmental impacts.

7.7 Identification of appropriate indicators: the importance of dialogue

There is no perfect indicator, but there are many indicators that are adequate for monitoring the environmental effectiveness of agri-environmental initiatives. The potential difficulties involved in indicator selection, however, strongly suggest that consultation with relevant experts and stakeholders is crucial to inform judgement on those indicators that are an acceptable trade-off against what is 'feasible, affordable and manageable'.

For their part, experts need to communicate the associated possible imperfections and limitations of indicators to policy-makers:

> Both the reasoning behind the choice of indicator and the methodology by which it is derived from available data should be communicated alongside the indicator itself together with any caveats or limitations to usage: transparency and relevance are crucial to the adoption and correct usage of indicators.
>
> (Moxey *et al.* 1998).

During this study, the involvement of expert researchers and stakeholders was very productive. The willingness of stakeholders to be involved and to contribute was a remarkable resource, and we have received many excellent suggestions and numerous comments that have improved the project. In turn, the pragmatic and focused nature of the stakeholder involvement with monitoring issues will ultimately contribute to the national debate on these issues.

A key issue in this study is the more precise definition of the objectives of agri-environment schemes and the desired environmental state to be achieved. As the REPS continues to modify existing measures and add new ones, the agri-environmental indicators may need to be changed in response. Continued dialogue with a range of agri-environmental stakeholders should provide valuable assistance to this process.

This study provided an important and rewarding opportunity for dialogue with specialists and stakeholders. The identification of indicators in this desk study was a necessary first step in the design of a monitoring programme for the REPS. Future discussion between policy-makers and such groups is important to further clarify the precise composition of the indicators for a more comprehensive monitoring of the environmental impact of the Rural Environmental Protection Scheme.

8 Summary of stakeholder feedback

Review comments from stakeholders were submitted via email (Coastwatch, Comhar, Birdwatch Ireland, Environmental Resource Management UCD and Biosystems Engineering UCD); verbal communication by telephone (Teagasc); written communication (An Taisce, IFA, Dúchas and a private consultant); and meetings (Coastwatch, Teagasc, Heritage Council and IFA). Further meetings were held with the Environmental Protection Agency and the Department of Agriculture and Food.

8.1 General comments

A selection of comments is provided below.

An Taisce is delighted that the process of identifying meaningful indicators for REPS has commenced, which we recommended in our report undertaken in the review and monitoring of REPS, published in January 2003
(An Taisce)

Really excellent approach to indicator selection, easy to follow and with transparent scoring approach. Will be very exciting to use and be a really strong stimulus for improvements. From experience coordinating the coastal PSR indicator research study with EUROSTAT, I hope that it will not be sitting in books but tried and then used as soon as possible.
(Coastwatch)

This is really useful and interesting. It is really bringing out the important elements of an effective evaluation approach. Two things I really like are the fact that it is put in the context of the broader impact of agriculture on the environment (rather than just focusing exclusively on the REPS), and the emphasis on measurable objectives and targets
(Ecologist)

On a general point, we would suggest that some assessment is made of the economic impacts of meeting the goal/targets for the selected indicators. Of course, it is recognised that part of the REPS payment is in respect of the

compensation for the agronomic costs in undertaking certain of the required REPS measures. However we feel that it is important that proper assessment of both the environmental and economic consequences for REPS farmers of participation in this scheme is constantly monitored
(IFA)

Collating all of the proposed variables was a great undertaking. [I recommend] a pilot study with representative farms (size of holding, farm enterprise type and regional location) to test the variables
(Consultant Ecologist)

8.2 Questionnaire responses

Stakeholders were supplied with a questionnaire. A selection and summary of responses is provided below. These comments were considered when finalising the list of indicators.

8.2.1 Scope of generic list of attributes

Q. Does the report contain a sufficiently broad scope of measurable attributes?

The general consensus was that the report covered a broad scope of attributes and there were no obvious omissions (see below for some additional suggestions).

Q. Are these indicators likely to be relevant to any future changes that may be made to the REPS? (e.g. if biodiversity/landscape issues are made more prominent in the scheme)

The response to this question varied with the stakeholder's background. It was an important consideration. While many of the indicators would only make sense in a future development of the scheme, some of the indicators were not considered realistic or practical options for a future assessment.

8.2.2 Selection criteria

Q. Do you agree with the nature of the selection criteria that were used?

Respondents broadly agreed with the range of selection criteria. There was some confusion in the interpretation of 'relevance' and 'reliability', which allowed us to clarify these definitions.

Q. Do you agree with the values attributed to the selection criteria, for the various indicators?

Most respondents did not comment to this level of detail. However, one stakeholder offered detailed comment on the potential value as indicators of invertebrate species such as carabid beetles, parasitoid wasps, spiders, insect pollinators, Hemiptera and Heteroptera.

Q. Are there indicators that should be included/excluded from the list of indicators that are appropriate to the REPS?

A number of stakeholders suggested that the biodiversity section should include reference to lichens, bryophytes, arable field bryophytes, frogs, spiders, syrphids, Hemiptera and bats.

The section on 'Genetic diversity' should make reference to old fruit tree varieties in farm gardens/hedges. The importation of 'wild flower meadow' in seed packets, especially to islands with their own subspecies or variant, should be stopped.

With respect to habitats, wetlands and coastal areas need to be included specifically.

The sustainable use of resources needs an indicator for farms which make efforts to reduce water and energy use (e.g. rainwater collection), including environmentally friendly or energy-efficient energy production methods (solar panel, water, windmill, extra insulation etc).

Indicator of (change in) farmers' environmental appreciation / environmental knowledge through REPS should be included, e.g. farmer questionnaire before and following REPS training course / KASA (change in knowledge, awareness, skills, aspirations) of REPS participants.

Cumulative effect of REPS may be greater in some areas than others e.g. in Nitrate Sensitive Zones. Environmental benefits of REPS are not equally weighted everywhere. Spatial analysis is required.

8.2.3 Target-setting

Q. Are the qualitative/quantitative targets appropriate?

The targets depend on the measurable variable and where a target was presented it was considered appropriate.

Q. Are there qualitative/quantitative targets that should be included/omitted?

Where respondents commented on this question, the overwhelming theme was that the REPS should provide positive management and encourage participating farmers to 'improve' and 'enhance' existing habitat/landscape quality. Also, the scheme should include opportunity to 'restore some species to former levels'.

Q. Can you suggest other processes or specific examples for determining the values of targets?

Respondents acknowledged the difficulties with this process and that it may fall to policy-makers to determine targets for national schemes.

8.2.4 Other issues

Q. Are there relevant issues that you would like to see elaborated upon or included?

This question prompted considerable comment, some of which is presented here. Several stakeholders raised a number of important questions:

- Who will do the monitoring?
- Who will coordinate the monitoring programme?
- How will independence be achieved?

One stakeholder commented that coordination will require a team that works together and which provides continuity of personnel. The monitoring programme also needs to be supervised/managed on a longer timescale to achieve continuity.

It was suggested that there should be major involvement of the universities to ensure independence.

The IFA pointed out that 'in connection with the measurement and monitoring of environmental indicators, we understand from our meeting that the measurement of

indicators will have no implications for the individual REPS participants concerned but rather will feed back into the overall assessment of the scheme itself ... This point needs to be properly communicated to those participants whose farms are selected for measurement of such indicators.'

It was further pointed out that issues relating to water quality require strong consideration. Water quality was a priority objective in the original design of the REPS.

A particularly perceptive comment from one stakeholder suggested the identification of two different types of indicators:

- **Effectiveness of implementation of agri-environmental practices.** The first set of indicators would assess how well the participants in the REPS implement agri-environmental practices that would *be expected* to have positive impacts on environmental quality, e.g. adequacy of the measures' design, adequacy of implementation, ability of planners to make it work, level of compliance.

- **Effectiveness of the REPS in delivering environmental improvement.** The second is a set of indicators that would assess whether the measures are having an effect, and how they are having an effect. Many of the suggested indicators do this. This set of indicators would be compiled by going through each measure and defining indicators to assess its effectiveness.

It was also pointed out that it would be useful to distinguish between indicators of actual outcomes, e.g. increased area of semi-natural grassland, and indicators of operational success, e.g. number of farmers renewing REPS membership.

Another suggestion was to link the indicator to a label (like a blue flag) if certain standards are achieved. This would promote farmers' image and pride in the scheme.

In their response, An Taisce referred to their own report *Monitoring and Evaluation of the Rural Environment Protection Scheme* (An Taisce 2002). They highlighted the need for a qualified ecologist to carry out an initial baseline survey of biodiversity on participating farms. This would bolster the information available for ongoing

monitoring and would allow both the quantity and quality of habitats to be determined.

9 References

An Taisce (2002) *Monitoring and Evaluation of the Rural Environment Protection Scheme*. An Taisce (The National Trust for Ireland), Dublin.

Aughney, T. and Gormally, M. (2002) The nature conservation value of lowland farm habitats on REPS and non-REPS farms in County Galway and the use of traditional farm methods for habitat management under the Rural Environment Protection Scheme (REPS). *Tearmann: the Irish Journal of Agri-Environmental Research* **2**: 1–14.

Bignal, E. and Baldock, D. (2002) Agri-environment policy in a changing European context. In *Conservation Pays?* ed. J. Frame. British Grassland Society Occasional Symposium **36**: 3–14.

BirdWatch Ireland (1999) *The Rural Environment Protection Scheme: Evaluation and Recommendations*. BirdWatch Ireland, Dublin.

Bohnsack, U. and Carrucan, P. (1999) *An Assessment of Farming Prescriptions under the Rural Environment Protection Scheme in the Uplands of the Burren Karstic Region, Co. Clare*. Heritage Council, Kilkenny.

Büchs, W. (2003) Biodiversity and agri-environmental indicators: general scopes and skills with special reference to the habitat level. *Agriculture, Ecosystems and Environment* **98**: 1–16.

Cameron, A., Millsopp, C.A. and McAdam, J.H. (1997) Biological monitoring of grasslands in the West Fermanagh and Erne Lakeland Environmentally Sensitive Area. In *Grassland Management in the Environmentally Sensitive Areas*, ed. R.D. Sheldrick, pp. 55–60. Proceedings of the British Grassland Society Conference, University of Lancaster, 23–25 September 1997. British Grassland Society, Reading.

Carey, P.D., Barnett, C.L., Greenslade, P.D., Hulmes, S., Garbutt, R.A., Warman, E.A., Myhill, D., Scott, R.J., Smart, S.M., Manchester, S.J., Robinson, J., Walker, K.J., Howard, D.C. and Firbank, L.G. (2002). A comparison of the ecological quality of land between an English agri-environment scheme and the countryside as a whole. *Biological Conservation* **108**: 183–197.

Clements, D.K. and Tofts, R.J. (1992) *Hedgerow Evaluation and Grading System: a Methodology for the Ecological Survey, Evaluation and Grading of Hedgerows*. Countryside Planning and Management, Cirencester.

Countryside Council for Wales (1996) *A Guide to the Production of Management Plans for Nature Reserves and Protected Areas.* Countryside Council for Wales, Bangor.

Deblitz, C. and Plankl, R. (1998). *EU-wide Synopsis of Measures According to Regulation 2078/92 in the EU.* Federal Agricultural Research Centre (FAL), Institute of Farm Economics, Braunschweig, Germany.

DAFRD (Department of Agriculture, Food and Rural Development) (1999) *Evaluation of the Rural Environment Protection Scheme operated under Council Regulation 2078/92.* Government of Ireland, Dublin.

DAF (2000a) *Rural Environment Protection Scheme, Specifications for REPS 2000.* Government of Ireland, Dublin.

DAF (2000b) *CAP Rural Development Plan 2000–2006.* Government of Ireland, Dublin.

DAHGI (Department of Arts, Heritage, Gealtacht and the Islands) (2002) *National Biodiversity Plan.* Government of Ireland, Dublin.

Dunford, B. and Feehan, J. (2001) Agricultural practices and natural heritage: a case study of the Burren uplands, Co Clare. *Tearmann: the Irish Journal of Agri-Environmental Research* **1**: 19–34.

Duelli, P. and Obrist, M.K. (2003) Biodiversity indicators: the choice of values and measures. *Agriculture, Ecosystems and Environment* **98**: 87–98.

EC (European Commission) (2000) *Common Evaluation Questions with Criteria and Indicators: Evaluation of rural development programmes 2000-2006 supported by the European Agricultural Guidance and Guarantee Fund*. European Commission, Directorate General for Agriculture, Document VI/12004/00.

Feehan, J., Flynn, M., Culleton, N., Gilmore, D.A. and Kavanagh, B. (2002a) REPS and the UN Convention on Biodiversity: agri-environment and biodiversity conservation. In *Achievement and Challenge: Rio+ 10 and* Ireland, ed. J. Feehan and F. Convery, pp. 29–36. Environment Institute, University College Dublin.

Feehan, J., Gilmore, D.A. and Culleton, N.E. (2002b) The impact of the Rural Environment Protection Scheme on plant and insect diversity. *Tearmann: Irish Journal of Agri-Environment Research* **2**: 15–28.

Finn, J.A. (2003) The agri-environmental measure of the Rural Development Regulation (1257/99): an overview of policy issues. *Tearmann: the Irish Journal of Agri-Environmental Research* **3**: 1–16.

Flynn, M., Kavanagh, B., Culleton, N. and Carton, O. (2002) An evaluation of the impact of the Rural Environment Protection Scheme on biodiversity using birds as bio-indicators. In *Conservation Pays?* ed. J. Frame. British Grassland Society Occasional Symposium **36**: 111–114.

Fossitt, J.A. (2000) *A Guide to the Habitats in Ireland*. Heritage Council, Kilkenny.

Goldsmith, F.B. (ed.) (1991) *Monitoring for Conservation and Ecology*. Chapman and Hall, London.

Hellawell, J. (1991) Development of a rationale for monitoring. In *Monitoring for Conservation and Ecology*, ed. F.B. Goldsmith, pp. 1–14. Chapman and Hall, London.

Hickie, D. (2000) *Development of a Methodology for the Assessment of the Impacts of Agriculture on the Environment Using Agri-Environmental Indicators.* Environmental Protection Agency, Wexford.

Hickie, D., Smyth, E., Bohnsac, U., Scott, S. and Baldock D. (1999) *A Report on the Impact of Agricultural Schemes and Payments on Aspects of Ireland's Heritage.* Heritage Council, Kilkenny.

Jones, D.G.L., Bignal, E., Lysaght, L., Baldock, D. and Phelan, J. (2003) *A Review of the CAP Rural Development Plan 2000–2006: Implications for Natural Heritage.* Heritage Council, Kilkenny.

Kleijn, D. and Sutherland, W.J. (2003) How effective are European agri-environment schemes in conserving and promoting biodiversity? *Journal of Applied Ecology* **40**: 947-969.

Kleijn, D., Berendse, F., Smit, R. and Gilissen, N. (2001) Agri-environment schemes do not effectively protect biodiversity in Dutch agricultural landscapes. *Nature* **413**: 723–725.

Knickel, K. 1999. Changes in farming systems, landscape, and nature: key success factors of agri-environmental schemes (AES). In *Changing Agriculture and Landscape: Ecology, Management and Biodiversity Decline in Anthropogenous Mountain Grassland.* Proceedings of EUROMAB Symposium, Austrian Academy of Sciences, Vienna, September 1999.

Lee, D.C. and Bradshaw, G.A. (1998) Making monitoring work for managers: thoughts on a conceptual framework for improved monitoring within broad-scale ecosystem management efforts. www.icbemp.gov/spatial/lee_monitor/preface.html

Lehane, M. (1999) *Environment in Focus: a Discussion Document on Key National Environmental Indicators*. Environmental Protection Agency, Wexford.

Lucey, J. and Doris, Y. (2001) *Biodiversity in Ireland: a Review of Habitats and Species*. Environmental Protection Agency, Wexford.

Lütz, M. and Bastian, O. (2002) Implementation of landscape planning and nature conservation in the agricultural landscape: a case study from Saxony. *Agriculture, Ecosystems and Environment* **92**: 159–170.

Magette, W.L. (1998) Factors affecting losses of nutrients from agricultural systems and delivery to water resources. In Carton, O.T. (ed.) *Draft guidelines for nutrient use in intensive agricultural enterprises*. Teagasc, Johnstown Castle, Wexford, pp. 6-31.

MAFF (Ministry of Agriculture, Fisheries and Food) (2000) *Towards Sustainable Agriculture: A Pilot Set of Indicators.* Ministry of Agriculture, Fisheries and Food, United Kingdom.

Mansvelt, J.D. van and Lubbe, M.J. van der (1999) *Checklist for Sustainable Landscape Management: Final Report of the EU-concerted Action (AIR3-CT93-1210). The Landscape and Nature Production Capacity of Organic/Sustainable Types of Agriculture*. Elsevier, Amsterdam.

McRae, T., Smith, C.A.S. and Gregorich, L.J. (2000) *Environmental Sustainability of Canadian Agriculture: Report of the Agri-Environmental Indicator Project. A Summary.* Agriculture and Agri-Food Canada, Ottawa.

Menge, M. (2003) Experiences with the application, recordation and valuation of agri-environmental indicators in agricultural practice. *Agriculture, Ecosystems and Environment* **98**: 443–451.

Moxey, A., Whitby, M. and Lowe, P. (1998). Agri-environmental indicators: issues and choices. *Land Use Policy* **15**: 265–269.

MTT Agrifood Research Finland (2002) *Agri-Environmental and Rural Development Indicators: a Proposal*. MTT Agrifood Research Finland, Jokioinen.

Noss, R.F. (1999) Assessing and monitoring forest biodiversity: a suggested framework and indicators. *Forest Ecology and Management* **115**: 135–146,

OECD (Organisation for Economic Cooperation and Development) (2001) *Environmental Indicators for Agriculture: Volume 3. Methods and Results*. OECD, Paris.

O'Sullivan, M. (2001) Farming and archaeology in rural Ireland today. *Tearmann: the Irish Journal of Agri-Environmental Research* **1**: 55–63.

Peco, B., Malo, J. E., Oñate, J., Saurez, F. and Sumpsi, J. (1999) Agri-environmental indicators for extensive land-use systems in the Iberian peninsula. In *Environmental Indicators and Agricultural Policy*, ed. F. Brouwer and B. Crabtree, pp. 137–156. CAB International, Wallingford.

Piorr, H.-P. (2003) Environmental policy, agri-environmental indicators and landscape indicators. *Agriculture, Ecosystems and Environment* **98**: 17–33.

Primdahl, J., Peco, B., Schramek, E. and Oñate, J.J. (2003) Environmental effects of agri-environmental schemes in western Europe. *Journal of Environmental Management* **67**: 129–138.

Romstad, E. (1999) Theoretical considerations in the development of environmental indicators. In *Environmental Indicators and Agricultural Policy*, ed. F. Brouwer and B. Crabtree, pp. 13–24. CAB International, Wallingford.

Speight, M.C.D. (2000) Syrph the net: a database of biological information about European Syrphidae (Diptera) and its use in relation to conservation of biodiversity. In *Biodiversity: the Irish Dimension*, ed. B. Rushton, pp. 156–171. Royal Irish Academy, Dublin.

Wascher, D. (ed.) (2000) *Agri-Environmental Indicators for Sustainable Agriculture in Europe.* European Centre for Nature Conservation, Tilburg.

Wilson, G.A. and Buller, H. (2001) The use of socio-economic and environmental indicators in assessing the effectiveness of agri-environmental policy. *European Environment* **11**: 297–313.

Appendix 1

Landscape indicators for measuring the agri-environmental impact of the Rural Environment Protection Scheme

Abbreviations: Rlv: relevance; Rli: reliability; Rsp: responsiveness; Log: logistical feasibility; Cst: cost; Dat: data availability

Landscape management									
Indicator	**Measurement**	**Reference**	**Rlv**	**Rli**	**Rsp**	**Log**	**Cst**	**Dat**	**Comment**
Participation	Number of REPS farms per unit area	Mansvelt & Lubbe 1999	5	5		4		5	Current REPS target – maintain participating farms and increase overall number
	Proportion of UAA in the REPS	Piorr 2003	5	5		4		5	Current REPS target – no decrease
	Number of farmers participating in training programmes concerned with environmentally friendly management practices		5	5		5		5	All REPS participants must attend a training programme
	UAA within protected sites (SPA, SAC, NHA)		5	5		4		5	Current REPS target – maintain where present.
	Number of REPS farms participating in Measure A		5	5		4		5	Current REPS target – increase
	Number of REPS farms / proportion of land participating in long-term set-aside supplementary measure.		5	5		4		5	Current REPS target – increase
	Number / area of land farmed organically		5	5		4		5	Current REPS target – increase
	Proportion of group REPS agreements in area		1						Currently there is no provision for group agreements in REPS
	Number of farms participating in biodiversity action plans		1						Biodiversity action plans are yet to be implemented; however, if/when established, they would be highly relevant

Landscape composition									
Indicator	**Measurement**	**Reference**	**Rlv**	**Rli**	**Rsp**	**Log**	**Cst**	**Dat**	**Comment**
Land use	Amount of UAA (in particular area / landscape)	Mansvelt & Lubbe 1999 MAFF 2000 Piorr 2003 Primdahl *et al.* 2003	4	4					Current REPS target – no decrease
	Tillage per UAA		3	3					
	Number of crops per arable area / number of crops in rotation		4	4	4			5	Current REPS target – increase crop diversity. Crop diversity is not prescribed in the REPS at present; however, increased crop diversity is often associated with positive landscape and biodiversity value. It can also act as an indicator of specialisation.
	Area of cereal margins under environmental management		5	5	4	3		3	Current REPS target – increase
	Permanent grassland per UAA		3	3		4			Current REPS target – maintain
	Area of land under forestry		4	4					Current REPS target – increase where suitable with suitable species. REPS participants cannot receive payment for native woodland scheme. Other forestry schemes becoming integrated with scheme (see Rural Development Plan).
	Afforestation rate		3	3					
	Area of semi-natural / non-cultivated land		5	5	5	3		3	Current REPS target – maintain current status
Land use change	Concentration / marginalisation	Piorr 2003	3	3					
	Intensification / extensification		3	3	3				The farm extensification programme influenced the rate of extensification more than the REPS

Landscape configuration									
Indicator	**Measurement**	**Reference**	**Rlv**	**Rli**	**Rsp**	**Log**	**Cst**	**Dat**	**Comment**
Diversity	Diversity indices: Land use diversity Habitat diversity	MAFF 2000 Piorr 2003	 3 4	 3 4					Current REPS target – maintain current landscape diversity patterns. Increase diversity, where suitable.
Shape/size	Mean patch / field size (of agricultural parcels)		4	4	4	5			Current REPS target – maintain field size, i.e. no increase. Smaller land parcels/fields are an indicator of increased field boundary and connectivity.
	Mean patch shape		2	2					Current REPS target – maintain
	Length and distribution of different edges		5	5	5			3	Current REPS target – maintain and increase where suitable. Smaller fields implies greater field boundary length.
Connectivity	Fragmentation indices		4	4	4	3			Current REPS target – reduce fragmentation. Connectivity of natural and semi-natural landscape features is an important element in habitat and wildlife conservation as it allows for movement and migration between areas.
	Connectivity of grasslands		3	3	2			3	Current REPS target – increase

Landscape features									
Indicator	**Measurement**	**Reference**	**Rlv**	**Rli**	**Rsp**	**Log**	**Cst**	**Dat**	**Comment**
Habitat distribution	Habitat inventories and vegetation maps for landscape		4	4	4	3		3–5	Current REPS target – increase
Habitat	Inventory of habitat types on farms (REPS)		5	5	5	3		1–3	Current REPS target – inventory of habitats (type and extent) on each participating farm
	Length of hedge (m) per UAA/ha	Primdahl *et al.* 2003	5	5	5	3		3–5	Current REPS target – maintain
	Area of semi-natural grassland		5	5	5	4		1–3	Current REPS target – maintain
Diversity of wildlife habitats	Habitat diversity indices	Mansvelt & Lubbe 1999 Lütz & Bastian 2002 Piorr 2003	5	4	3	3		1	Current REPS target – maintain
	No. of farms with >3, >6 habitats		5	4	4	3		3–5	Current REPS target – maintain
	No. of farms with minimum of 3–6% natural/semi-natural area		5	4	4	3		1–3	Current REPS target – maintain
	No of farms with >15% habitat		5	4	4	3		1–3	Current REPS target – maintain
	Habitat removal (ha)		5	5	5	4		3–5	Current REPS target – prevent
	Habitat creation (ha)		2	2					Current REPS target – encourage
	Net change (ha)		5	4	4	3		1–3	
Linkage among wildlife habitats	Connectivity indices		4	4	4	3	3	3–5	Current REPS target – maintain, increase where suitable

Landscape features (continued)									
Indicator	**Measurement**	**Reference**	**Rlv**	**Rli**	**Rsp**	**Log**	**Cst**	**Dat**	**Comment**
Tree cover	Plantations on REPS farms Previous land use Mostly conifer Deciduous / conifer Mostly deciduous		5	5	5	4		5	Current REPS target – increase where suitable, increase proportion of native broadleaved species
	Woodland on REPS farms Mostly conifer Deciduous / conifer Mostly deciduous		5	5	5	3		3–5	Current REPS target – maintain where present. Woodland: i.e. not commercial plantation.
Watercourses and wetlands	Present/absent		5	3	2	5		5	
	Type of watercourse / wetland		4	4	3				
	Water quality		4	2	2–3	2			Current REPS target – maintain / improve water quality
	Occurrence of salmonid water course		4	4	2–3	2			
	Stockproof/ fencing of watercourses		5	5	5	5		5	
Conservation status	Number of farms in Special Areas of Conservation		5	5	4	5			Current REPS target – increase
	Number of farms in Natural Heritage Areas		5	5	4	5			

Public access and information									
Indicator	**Measurement**	**Reference**	**Rlv**	**Rli**	**Rsp**	**Log**	**Cst**	**Dat**	**Comment**
Public access	Length of pathway provided on a farm Total length of continuous pathway across several farms Number of stiles provided		1						Although possible in REPS 1, public access is no longer eligible for payment within REPS
	Angling facilities		2						
Public information	Information on public access		1						
	Information on local heritage		1						

Archaeology and built heritage									
Indicator	**Measurement**	**Reference**	**Rlv**	**Rli**	**Rsp**	**Log**	**Cst**	**Dat**	**Comment**
Archaeology	Features of archaeological and/or historical interest		5	5		3–4		3–5	Current REPS target – maintain and protect where present
	Average number of features per farm on sites and monuments register (SMR) Average number of new features per farm not previously recorded on SMR	DAF 1999 O'Sullivan 2001	5 5	5 5		3 3		3–5 3	Current REPS target – identify
	Length of hedgerow pre-dating AD 1700	O'Sullivan 2001	4	4		2–3		3–5	Current REPS target – identify
	Proportion of farmers that practise active management of heritage features, e.g. fencing off, restoration, allow grazing		4	5		3		1–3	Current REPS target – increase

Farmyard appearance									
Indicator	**Measurement**	**Reference**	**Rlv**	**Rli**	**Rsp**	**Log**	**Cst**	**Dat**	**Comment**
Buildings	Presence / occurrence of traditional farm buildings, listed buildings e.g. limestone, granite, sandstone used in original construction		5	5		5		3	Current REPS target – maintain, and improve where in disrepair
	Proportion of farmyard given to shelter/tree cover		5	5	3	4		1–3	Current REPS target – increase
	Farmyard colour scheme (traditional colours)		5	5	4	4		3–5	Dark colours on roof include dark grey, dark blue, deep red-brown, dark brown, very dark green. Suitable wall colours: grey, blue/grey, brown, light reddish brown, whitewash or unpainted block or plastered wall colours. Colour should be influenced by tradition in the locality.
Farmyard appearance	Litter / farm refuse management Plastic recycling (fertiliser bags, silage wrapper)		5 5	5 5	5 4	4 4		3–5	
	Boundary maintenance in farmyard		5	5	5	3			

Farmyard appearance (continued)									
Indicator	**Measurement**	**Reference**	**Rlv**	**Rli**	**Rsp**	**Log**	**Cst**	**Dat**	**Comment**
Farmyard wildlife	Provision for nesting birds in farm buildings		5	4	2–3	3		1–3	Current REPS target – promote
	Proportion of farm buildings with nesting								
	Barn Owl		5	5		3		1–3	Current REPS target – maintain
	Swallow		3	3		3		1–3	
	House Martin		3	3		3		1–3	
	Provision of nest boxes		2						Current REPS target – promote and increase
	Provision for bats in farm buildings		5	4	2–3	3		1–3	Current REPS target – promote
	Proportion of farm buildings with bats		5	5		3		1–3	Current REPS target – promote and increase
	Provision of bat boxes		2						Current REPS target – promote and increase

Appendix 2

Biodiversity indicators for measuring the agri-environmental impact of the Rural Environment Protection Scheme

Abbreviations: Rlv: relevance; Rli: reliability; Rsp: responsiveness; Log: logistical feasibility; Cst: cost; Dat: data availability

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Genetic diversity	The total number of crop varieties/livestock breeds that have been registered and certified for marketing	OECD 2001 EC 2000	2					5	Scale: National REPS supplementary measure 'rearing animals of local breeds in danger of extinction' does not include cultivated plants
	The share of key crop varieties in total marketed production for individual crops	MTT 2002	2						
	The share of the key livestock breeds in respective categories of livestock numbers	Wascher 2000	3						Government committee established in 1996 to examine genetic resources in Ireland
	The number of endangered national crop varieties/ livestock breeds		3				5	5	Context indicator
Domestic animal diversity	Classification of the breeds and sub-populations within a breed	MTT 2002	4						As above
	Distribution of populations								
	Estimation of the effective population size of the breeds and genetic distinctiveness of the breeds		4						

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Domestic animal diversity (continued)	Total number of REPS participants adopting Rare Breeds supplementary measure	DAF 2000b	5	5	5	5	5	5	Current REPS target – increase from 200 (1994–1999) to 350 by 2006.
	Number of registered Kerry breeding females under REPS / National figure		5	5	5	4		5	Existing indicator with targets from DAFRD for these species.
	Number of registered Irish Maol breeding females under REPS / National figure		5	5	5	4		5	Initially this measure also included Dexter cattle, Connemara Pony (not included in REPS 2)
	Number of registered Irish Draught breeding females under REPS / National figure		5	5	5	4		5	
	Number of registered Galway ewe breeding females under REPS / National figure		5	5	5	4		5	Not included in REPS 2

Wildlife: species diversity	Topics:	OECD 2001							Species diversity takes into account both species richness and the relative abundance of species. Different species groups respond to changes at specific spatial scales; several species groups are required to express change in agriculture, e.g. birds, vascular plants, butterflies, bees etc.
	Native species	MTT 2002	5	5	3	2		1	
	Non-native species		1						

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Wildlife: species diversity (continued)	Species richness	EC 2000	5	5				1	Species richness measures the number of species present in an area/community. Need to employ specific groups of species/taxa as total species diversity is unfeasible. Flagship species are species of considered importance e.g. specific birds or butterflies. Species population trends require a time series of data.
	Flagship species	Wascher 2000	4	4				1	
	Species population trends		5	3				1	

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Farmland bird diversity	Number of bird species present in winter		4	3	2	3	2	1	Current REPS target – maintain, restore
	Number of bird species present in summer		4	3	2	3	2	1	
	Presence/absence of particular bird species		4	3	2	1	2	1	Current REPS target - conservation of rare of threatened birds
	Conservation status of species present (endangered/ red-amber-green listed)		5	4	2				
	Ground-nesting birds		3						Birds are mobile organisms; thus, monitoring can be conducted on a landscape scale.
	Species identified in National Biodiversity Plan		4	4	3	1		1	
	Population census		5	4	3	1	2	3	
	Number of breeding pairs/colonies		3	3	2	1	1	1	Data availability is scored on a per farm basis. There may be more information on a national scale but it may lack quantitative power.
	Number of clutches		3	3	2	1	1	1	
	Fledgling survival rate								

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Bird population changes	Population size of key farmland bird species e.g Corncrake, Yellowhammer	MAFF 2000	5	3	3	2		3	Popular indicator. Public can readily identify with farmland birds.
	Changes in populations of an assemblage of common farmland bird species	MTT 2002 Hickie 2000	5	3	2	1		3	Long-term data sets are required to monitor population trends.
	Changes in populations of individual farmland bird species	Lehane 1999	5	4	2	1		3	Could be facilitated by incorporating Countryside Bird Survey data.
	Change in total bird population	DAF 2000b	5	3	3			3	While they may not show rapid response to management change in some instances they do conform to many of the requirements of indicator taxa.
	Total number of bird species		5	1	1			5	
	Average number of bird species /farm		5	2	3	2		1	
	Average number of breeding bird species /farm		5	2	3	1		1	Limited quantitative data available

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Breeding waders and waterfowl	Size of area of suitable habitat		5	5	5	4		5	As highly mobile organism, the occurrence or otherwise of particular bird species will be influenced by factors operating outside the farm scale. Therefore, indicators of habitat and landscape are required in conjunction with any bird index.
	Number of species of waterfowl		5	5	2–3	2		1	
	Estimated population sizes		5	4	3	2	1		
	Number of clutches		3	2	2	1	1		
	Fledgling survival		3	2	2	1			
	Timing of mechanical operations		4	4	4	4		1	
	Timing of grazing/mowing		5	5	5	4		1	
	Application of fertilisers		5	5	5	4		1	
	Application of slurry		5	5	5	4		1	
Invertebrate diversity	Trends in diversity and distribution of selected invertebrate groups	MTT 2002	5	3	3	1		3	Current REPS target – maintain, restore.
		Kleijn *et al*. 2001							Popular biological indicator, distribution atlas data available.
	Pollinators:								
	Butterflies and moths (e.g. population change index by habitat)	Cameron *et al*. 1997	5	3		1		3	Various invertebrate groups are used in ecological impact assessment. Various groups act as surrogates of overall diversity. In general it is recommended to use more than one group as they may reflect different spatial scales.
	Bees		5	3		1		1	
	Hoverflies	Speight 2000	5	3		1		3	
	Other groups:								
	Carabid beetles	Feehan *et al*. 2002b	5			3		3	
	Spiders		4			2		1	
	Parastoid wasps		4			1		1	
	Collembola		4			2		1	
	Staphylinid beetles		4			2		1	

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Threatened species	Trends in distribution and abundance of threatened species of fauna dependent on agricultural practices	Hickie 2000 Lehane 1999	5	3	3			5	One of central aims to protect endangered species of flora and fauna. Need to establish if threatened species present on farms.
	Trends in threatened species of flora dependent on agricultural practices	MTT 2002	5	4	3			3	These indicators would complement the national Biodiversity Action Plan for individual species of conservation concern.
	Introduction on REPS farms of conservation action plans for threatened species		5					1	Long term data /time series data sets is required to monitor trends.
Botanical diversity	Botanical diversity of field margins		5	4	3	3	2	3	Current REPS target – maintain, restore.
	Botanical diversity of semi-natural grassland		5	4	3	3	2	3	Most habitats are characterised according to floral composition.
	Diversity of non-cultivated plants/arable weeds		5	4	3	2	2		Plant diversity can act as a surrogate for the diversity of other taxa that are adapted to the presence of host plant species.
	Proportion of competitor, stress-tolerator and ruderal species		5	5	4	2	2	1	
Lichen diversity	Tree lichen diversity		4	4	3			1	
	Presence of key lichen species		4	4	3			1	
	Diversity of ground lichens (e.g. on areas of bog /sand dune)		4	4	3			1	

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Conservation value of wildlife habitat	EU: listed in Habitats Directive		5					1	
	National: actions/targets identified in National Biodiversity Plan		3					1	Specific actions and targets not yet developed under national /local biodiversity plans
	Local: actions/targets identified by local biodiversity action plan		5					1	
Habitat diversity quantification	Intensively farmed agricultural habitats	OECD 2001	2						Current REPS target – maintain habitat heterogeneity/diversity
	Semi-natural agricultural habitats		5	5	3			3	
	Uncultivated natural habitats		5	5	4			3	Habitat diversity is a good indicator of species diversity. Much of the loss of biodversity is related to the loss of habitat diversity / heterogeneity in the agricultural landscape
	Habitat matrix/ Indices of agricultural diversity		3						
	Density of linear elements and diversity of land cover	EC 2000	5	5	5	3		3	
	Areas of high nature value	Mc Rae *et al*. 2000	5	5	4			5	
	Length of hedgerow (m) per ha (edge density of fields km/ha; corridors and linkages; average total length of hedgerow per farm)	Primdahl *et al*. 2003 MTT 2002 Wascher 2000 DAF 1999	5	5	5	5	5	5	Current REPS target – maintain Management of REPS hedgerows is currently set at 140 m/ha/yr.
	Area of cereal margins under environmental management	MAFF 2000	5	5	5				Current REPS target – increase Relevant to tillage farms enrolled in REPS.

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Habitat diversity quantification (continued)	Area of semi-natural grassland	MAFF 2000	4	5	5	3		3	Current REPS target – maintain/increase Need to define the types of semi-natural grassland (Fossitt 2000)
	Inventory of habitat types on farms (average number of habitats per farm) Area and percentage cover of characteristic habitat types Habitats listed in REPS Callows Turloughs Marshs Swamps Peatlands Sand dunes Machairs Eskers Natural and semi-natural vegetation Woodlands Scrublands Lakes, ponds, rivers and streams Field boundaries/margins, hedgerows and stone walls Old buildings inhabited by protected species such as Barn Owl and bats Disused quarries	DAF 1999	5	5	5	3	3	4	Current REPS target – increase the proportion of land classified as habitats on farmland. There is little quantitative information on the occurrence of habitats (outside of designated areas) on farmland. As advocated by the Heritage Council (Ireland) 1999. There is concern that habitats outside of NHA/SAC are not adequately identified and inappropriate management occurs as a consequence. Training issue for REPS planners.

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Habitat diversity quantification (continued)	Condition of important wildlife/habitats on farmland/habitat quality of Natural Heritage Areas (NHAs)/ Special Areas of Conservation (SACs) managed under REPS	MAFF 2000 Hickie 2000	5	3	4	1	1	1	Condition of habitats could be evaluated using combination of more specific indicators. Monitoring of NHAs: responsibility of Dúchas.
	Total land area covered by REPS Measure A	Hickie 2000	5	5	5	5		5	Current REPS target – increase to 14,000 participants by 2006
	Area of different categories of designated natural areas managed under the REPS e.g. blanket bogs, heaths and upland grasslands, sand dunes, machair and Burren foothills		5	5	5	5		3	

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Tillage field margins (Conservation headlands, beetle banks in arable fields)	Length and width of headland		5	5	5	3	3	3	Current REPS target – >1.5 m. Evidence to show that REPS tillage margins > non-REPS (Feehan *et al.* 2002b, Flynn *et al*. 2002). *Recommendation*: extend this to 3 m. Current REPS target – decrease proportion of CSR species compared to perennial non-invasive field flora Current REPS target – increase plant species diversity and promote perennial, non-invasive field margin flora The active creation of conservation headlands and beetle banks is not an option under current REPS. However, there are management requirements for arable field margins.
	Number of plant species sown per unit area (where reseeded)		1						
	Number of plant species in sward per unit area		1						
	Dominant species		4	4	3	4	3	1	
	Proportion of competitor, stress-tolerator and ruderal species (CSR)		5	4	4			1	
	Proportion of grass species		4	4	3			1	
	Proportion of broadleaved plant species		4	4				1	
	Proportion of bare ground		4	4					
	Presence of desirable plant species, e.g. tussock-forming species and those attractive to invertebrates		4	4	3			1	
	Height of sward in mid-summer		3	3	3			1	
	Absence of pernicious weeds		5	4	4			1	
	Time since last ploughed		5	5	5			5	
	Time since last mown		5	5	5			5	
	Time since last grazed		5	5	5			5	
	Time since last application of slurry or fertiliser		5	5	5			5	
	Time since last application of herbicide		5	5	5			5	

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Field margins in grassland	Length and width of field margin		5	5	5	4	2	3	Current REPS target – minimum of 1.5 m no-spray zone: recommend increase to 3 m. Current REPS target – increase plant species diversity and promote perennial non-invasive field margin flora. Current REPS target – decrease proportion of CSR species compared to perennial non-invasive field flora. Reduce dominance of *Lolium*, *Agrostis*, *Dactylis*. Plant species richness in field margins did not differ significantly in a sample of REPS and non-REPS farms (Feehan *et al.* 2002b). On grassland, many field margins are fenced off. There is evidence that fencing off decreases plant species diversity over time if there is no mowing or grazing.
	Number of plant species sown per unit area		1						
	Number of plant species in sward per unit area								
	Dominant species		5	5	4	3			
	Proportion of competitor, stress-tolerator and ruderal species (CSR)		5	4	4	3			
	Proportion of grass species		5	4	4	3			
	Proportion of broadleaved plant species		5	5					
	Proportion of bare ground		5	5	5	3			
	Presence of desirable plant species e.g. tussock-forming species and those attractive to invertebrates		4	3		3			
	Height of sward in mid-summer		4	4	4	3			
	Absence of pernicious weeds		3	3	4	3			
	Time since last ploughed		5	5	5	5		5	
	Time since last mown		5	5	5	5		5	
	Time since last grazed		5	5	5	5		5	
	Time since last application of slurry or fertiliser		5	5	5	5		5	

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Grassland habitat Semi-natural grassland: dry calcarious and neutral grassland, dry meadows, dry-humid acid grassland, wet grassland.	Vegetation type As in the Heritage Council's *Guide to Habitats in Ireland* For each grassland type identified: Area of each grassland habitat on farm Number of plant species per unit area Presence of desirable plant species Presence of plant species identified in Red Data Book as threatened or rare Population size of particular plant species Flowering/seeding of desirable plant species Proportion of competitor, stress-tolerator and ruderal species (CSR) Absence of pernicious weeds Timing and frequency of mowing Timing and stocking density of grazing Provision of supplementary feed Time since last ploughed Time since last mown Time since last grazed Time since last application of slurry or fertiliser Application rates of nutrients Time since last application of herbicide	Fossitt 2000	5 5 5 4 5 3 3 4 5 5 5 4 5 5 5 5 5 5	 5 5 5 5 4 3 5 5 5 5 5 5 5 5 5 5	 5 4 4 4 3 3 4 4 4 4 5 5 5 5 5 5	 3 3 3 2 1 1 2 4 4 4 5 5 5 5 5 5	 	 5 1 1 1 4 4 4 5 5 5 5 5 5	Current REPS target – maintain area of species-rich grassland. Current REPS target – preserve characteristic flora. – protect threatened species of flora. – increase perennial non-invasive field flora – management suited to local conditions. Relevant to Annex 1 of Habitats Directive (Directive 92/43/EEC)/ SAC/NHA. The conservation value of many grassland habitats is dependent upon traditional farming methods and the timing of agricultural practices. Recommendations and targets should be set at a local/regional level.

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Hedgerow characteristics REPS hedgerow management 140m/ha/yr	Total length of hedgerow per unit area/farm		5	5	5	4	5	5	Current REPS targets
	Hedgerow height (mean hedgerow height, diversity of hedgerow heights)		5	5	5	3		1	– maintain or restore hedgerows, replanting where suitable
	Width (<1m, 1–2m, >2m)		5	5	5	3		1	– minimum hedgerow height of 1.5m
	Connectivity between hedgerows and other natural / semi-natural habitats (e.g. woodland)		4	5	3	4		3	– maintain / increase connectivity. – preserve existing trees/ increase number of trees.
	Species richness		5	3		3		1	
	Density (length or volume of hedge per ha)		5					3	A diversity of hedgerow structure is
	Shape (Triangular ; box-shaped; rounded; irregular		3	3	4	2		1	important to increase habitat heterogeneity. Hedgerow height and
	Management frequency: regular/irregular		5	5	5	5		5	width are positively correlated with
	Number of mature trees		5	5		3		1	bird/wildlife diversity and density.
	Dominant tree species		3			3		1	
	Dominant plant species		4		4	2		1	[UK system of grading hedges:
	Gappiness		5	5	4	3		1	Important hedges have at least 5–7
	Fence: present/absent stockproof		5	5		3			woody species /30m length and are associated with a number of associated features (bank, <10%
	Wall: present/absent stockproof		4	4		3			gaps, 1 tree/50m, at least 3 woodland plant species, a ditch, connections with other hedges)].
	Bank: height width vegetation		4	4		3			A combination of hedgerow characteristics is an indicator of hedgerow quality. These values
	Watercourse/drain: present/absent stockproof		4	5		3			similar to that used in hedgerow grading system (Clements and Tofts 1992), and hedgerow survey
	Grass verge/margin: width		5	5		3			organised by Networks for Nature. Hedgerows and other linear features
	Farm track/road: width		3						can act as habitat corridors for wildlife.

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Watercourses	Width		3			3		1	
	Height of bank		3			3		1	Certain rivers qualify for this
	Depth of water		2			3		1	supplementary measure
	Slope of sides		3	5	3	3		1	
	Number of aquatic plant species		5	5	3	3		1	Current REPS target – maintain,
	Proportion of area covered by aquatic plant species		5	5	4	2		1	restore aquatic vegetation
	Emergent vegetation present		3	4	3	3		1	Rotational management for clearing
	Width of buffer strip between water course and agriculturally managed area		5	5	5	4		1	of watercourses
	Frequency and timing of management		5	5				5	No fertiliser application within 1.5m of watercourse
Long-term set-aside along riparian zones	Width of set-aside area		5	5	5	4		5	Current REPS target – min 10m, max
	Fencing off of area		5	5	5	4		5	30m.
	Width of adjacent water channel		2			3		1	Current REPS target – increase from
	Depth of adjacent water channel		2					1	100 (1994–99) to 200 farms.
	Proportion of riffle, pool, glide in adjacent water channel		1			3		1	Work by Feehan *et al*. (2002b) questions the fencing off of
	Salmonid diversity		3	2	2	1		3	waterways, particularly smaller
	Freshwater invertebrate diversity		2					3	drainage channels. Decreased grazing
	Vegetation cover		5	4	4	3		1	caused by fencing results in reduced
	Botanical diversity		5	5	4	3		1	floral diversity.
	Proportion of competitor, stress-tolerator and ruderal species (CSR)		4	5	4	3		1	Current REPS target – decrease proportion of CSR species
	Tree planting in the set-aside area		5	5	5	3		5	Current REPS target – 50% tree cover. Current REPS target – allow vegetation to develop naturally. Current REPS target –promote the planting of oak / beech / willow / birch / ash / whitethorn / blackthorn / elder.

Appendix 3

Agronomic indicators for measuring the agri-environmental impact of the Rural Environment Protection Scheme

Abbreviations: Rlv: relevance; Rli: reliability; Rsp: responsiveness; Log: logistical feasibility; Cst: cost; Dat: data availability

Selected agricultural practices and nutrient management / water quality indicators for measuring and monitoring the environmental impact of the Rural Environment Protection Scheme (REPS)									
Indicator	**Measurement**	**Reference**	**Rlv**	**Rli**	**Rsp**	**Log**	**Cst**	**Dat**	**Comment**
Input use: 1. Nitrogen	Inorganic N fertiliser sales		5	5	4	4		5	National Farm Survey and Fertiliser Use Survey.
	Trends in usage of N		5	5	4	4		5	Data available from individual farm records (Measure 11).
	Type of fertiliser used (e.g. urea, calammonium nitrate etc.)		5	5	3	4		5	Urea is recommended for early grass while CAN for 2nd cut (Teagasc advice).
	Stocking rate (contribution of organic N)		5	5	4	4		5	
	Reduction in livestock units per UAA		5	5	4	4		5	
	Clover cover (contribution of clover to N availability)		4	4	4	3		3	
	Total N (organic and mineral)		5	5	4	4			Total of 260 kg/ha REPS (related to stocking rate). Maximium of 170 kg/ha can come from animal waste.
	Autumn soil testing for residual N		3	4	4	2		1	Multiple factors (inc. clover cover) affect N levels, but N in the root zone is a predictor of an environmental effect
	Number of cuts of silage per annum		4	4	4	4		3	
Nutrient efficiency: Nitrogen	Nutrient balance N (farm gate)	OECD 2001 MTT 2002	5	3	3	2		3	

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Input use: 2. Phosphorus	Inorganic P fertiliser sales	OECD 2001	5	5	4	4	4	5	
	Trends in usage P fertiliser		5	5	4	4	4	5	
	Type of inorganic fertiliser (e.g. soluble P vs. ground rock phosphate)		5	4	2	4	4	3	Rock phosphate not widely used in agriculture
	Stocking rate (contribution of organic P)		5	5	5	4	4	5	
	Soil test phosphorus level	MTT 2002	5	5	3	5	5	5	
	Change in phosphorus index over time		5	5	2	3	4	3	
	Proportion of agricultural soils at different phosphorus levels	MAFF 2000	4	5	2	3	4	3	
	Nutrient balance P (farm gate)	OECD 2001	5	4	3	3	3	1–3	
Nutrient efficiency: Phosphorus	Timing of inorganic fertiliser application	Knickel 1999	5	5	5	4	4		Applications should be made according to crop needs to make best use of nutrients.

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Fertiliser management	Soil pH		5	5	3	4	4	3	Target of pH = 6.5 for mineral soils
	Lime use		5	5	4	4	4	3	
Methods used to prevent fertiliser being spread into hedgerows and watercourses	Spout type spreaders (Vicon, Abbey)								In general, REPS farmers may not possess technically advanced spreaders which are only economical on more intensive farming systems. The use of contractors for fertiliser spreading and harvesting increases the variation in appropriate management of field margins. In general, farmers will adapt to measures that can be accomplished in the tractor cab.
	Lower height of machine on tractor	T. Fortune pers. comm.	4	3–4	4	4		1	
	Decrease PTO speed		4	3–4	4	4		1	
	Tilt spreader on tractor		4	3–4	4	4		1	
	Single disc spreaders								
	As above		"	"	"	"		"	
	Twin disc spreaders								
	Deflector plate e.g. Justobord, Ecobord (Sulky)								
	Trend system (Bøgballe) spreading discs rotate away from each other								
	Use of limitation guard/ boundary spread limited								
	Boundary spread discs (Amazonen)								
	Contract operators								
	Depends on the machinery, and on spray methods								
	Distance of tramlines from hedgerow / waterbody (tillage)		4	4	4	4	4	1	

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Organic manure	Organic manures integrated into nutrient management plan	OECD 2001 Knickel 1999	5	5	5	5	5	5	In line with REPS plan
	Amount of manure/slurry spread on land		4	4	4	3	4	3	(Of 260kg/ha N permitted, 170kg/ha can come from animal or other wastes)
	Timing of organic nutrient/ manure applications		5	5	5	3	4	1	
	Location of organic nutrient/ manure application (Uniformity of spreading)		4	4	5	3	4	1	
	Type of manure		3	4					
	C : N ratio of organic nutrient / manure		3	3		2	2	1	
	Types of machinery used to apply slurry and farmyard manure, e.g. low-trajectory /. downward-splash spreaders, injection or band spreading sideflinger (farmyard manure)		3	3	3	4			
	Buffer zones around watercourses and wells and hedgerows / field margins		5	5	5	4		3	

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Management of animal wastes and other farmyard waste	Months of available slurry storage on the farm		5	4	5	4		1–3	
	Storage method for slurry (includes storage capacity), design (including capacity) and siting of the storage facilities with their relevant equipment (e.g. access, agitation and emptying equipment)		5	5	5	4			
	Storage method and management of farmyard manures (area covered)		5	5	5	4		1–3	
	Techniques employed to decrease dirty farmyard area		5	5	5	3		1	
	Presence/absence of system to separate clean and dirty water		5	5	5	4			
	Dirty water disposal Into slurry tank Separate storage + spreading Wetland Irrigation Earthen bank tank		5	5	5	4			
	Silage storage (including silage effluent management)		5	3	4	3		1	
	Quality of silage pit		5	4	5	3	3	1	

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Pesticides	Intensity of use of pesticides Volume used, toxicity	OECD 2001	4	4	5	4		1	
	Types of pesticides used		4	4	4	2	3	1–3	
	Application methods / spray drift prevention		5	4	4	3		1	
Water quality	Nitrate losses from agriculture to fresh water in selected catchments	MAFF 2000	5	4	3	2	2–3	1–3	Nitrogen loss/transport risk ranking scheme (see Magette 1998) Very difficult to estimate but would be valuable indicator
	Phosphorus losses from agriculture to fresh water in selected catchments	MAFF 2000	5	4	3	1	2	1	Very difficult to estimate but would be a valuable indicator
	Phosphorus loss / Transport Risk ranking scheme (see Magette 1998)		5	4	3	2–3	2–3	1–3	
	Physical / chemical analysis of water quality		5	5	4	3	2	1–3	Measured on streams originating on farm.
	Biological index of on farm streams		5	5	4	4	1	1	Comparison of sites immediately above and below farm
	Condition of receiving waters (groundwater and surface water)	Magette 1998	4	4	4	4	1	1–3	

Indicator	Measurement	Reference	Rlv	Rli	Rsp	Log	Cst	Dat	Comment
Water quality (continued)	Length / proportion of watercourse fenced off		5	5	5	4	4	1–3	
	Width and length of riparian vegetation adjacent to watercourse (intercept groundwater discharge)		5	5	5	4	4	1	
	Water quality of farm wells		5	5	5	3	2	1	
	Presence of pathogens and nitrates in farm wells		4	4	3–4	3	2	1	
Livestock density	Reduction in livestock units per UAA		5	5	3–4	4	4	1–3	
	Rough grazing / uplands livestock units per grassland and fodder crops area		5	5	3–4	4	3–4	1–3	