

**WILD FLORA AND FAUNA IN IRISH AGRO-ECOSYSTEMS: A
PRACTICAL PERSPECTIVE ON INDICATOR SELECTION**

Jane Feehan¹

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¹ Trinity College, Dublin and Teagasc. The Irish Agriculture and Food Development Authority. The research discussed here is undertaken as part of a Teagasc Walsh Fellowship Ph.D.

Wild flora and fauna in Irish agro-ecosystems: a practical perspective on indicator selection

Jane Feehan

Trinity College, Dublin and Teagasc¹

Abstract

The traditional landscapes and associated biodiversity of many countries are to a large extent the result of many centuries of agricultural production. Indeed, many habitats and their associated wildlife communities are sustainable only through the continuation of the farming practices which created them.

Agri-environment schemes are an important tool in managing the impact of agricultural practices on biodiversity. They have a particularly important role to play in Ireland because of its exceptionally high proportion of agricultural land.

A study assessing the impact of Ireland's agri-environment scheme on plant and invertebrate diversity is described. Species indicators which are characteristic of important assemblages and habitats are a useful and important component of evaluation, and the process whereby they are selected is outlined. Although species indicators vary across different habitats, it is important that objective, standardised criteria are used to define and select them. Such criteria include habitat sensitivity, geographic spread and ease of identification.

Baseline data are fundamental to all monitoring studies. A baseline should be set according to the methodology used thereafter in monitoring, in order for it to serve as an appropriate basis for comparison.

The development of species indicators will assist in the monitoring of wild species dependent on, and affected by, agricultural practices.

Keywords

Baseline data, indicator selection criteria, REPS (Rural Environment Protection Scheme), Ireland.

Introduction

¹ The Irish Agriculture and Food Development Authority. The research discussed here is undertaken as part of a Teagasc Walsh Fellowship Ph.D.

Agriculture and Biodiversity

Until recently, agricultural land was not regarded as important for wildlife. Conservation activities had developed to focus almost entirely on protected sites. However, an appreciation is emerging of the importance to biodiversity of farming activities. Many of the 'wildest' areas of Europe are in fact farmland, and farming has been the major influence in creating many valuable landscapes, habitats and wildlife communities across the continent. Such habitats and their associated wildlife communities are sustainable only through the continuation of farming (McCracken and Bignal 1998, Bignal 1998).

With more than half of the total area of Europe being used for agriculture, the implications of agricultural practices have critical importance for European landscapes and biodiversity. In Ireland, over 75% of land use is agricultural, and the majority of this consists of grassland. Therefore, the link between agriculture and biodiversity is particularly strong in Ireland. Indeed, the first national report on the implementation of the UN Convention on Biological Diversity (CBD) in Ireland acknowledged that agriculture is the single biggest influence on biodiversity in Ireland (Dept of Arts, Heritage, Gaeltacht and the Islands, 1998).

Agri-Environment and Biodiversity Conservation

Agri-environment schemes are a significant tool in biodiversity conservation (Ovenden *et al.* 1998). The linking of biodiversity and agri-environment objectives is an important step towards achieving a more sustainable agriculture.

The agri-environment regulation, Council Regulation No (EEC) 2078/92, provides for programmes to encourage farmers to carry out environmentally beneficial activities on their land. Farmers receive payments in recognition of the costs and income losses incurred in providing this environmental service. All EU Member States are required to apply agri-environment measures throughout their territories, according to environmental needs and potential. Two broad types of environmental objective are evident (Fay 1998):

- To reduce the negative pressures of farming on the environment, in particular on water quality, soil and biodiversity;
- To promote farm practices necessary for the maintenance and enhancement of biodiversity and landscape, including the avoidance of degradation and fire risk from under-use.

Agri-environment has a particularly significant role to play in countries such as Ireland which have an exceptionally high proportion of agricultural land.

Agri-Environment in Ireland: The Rural Environment Protection Scheme (REPS)

The Rural Environment Protection Scheme (REPS) is Ireland's agri-environmental scheme, introduced in 1994 in response to EC Regulation 2078/92. The REPS is a voluntary, horizontal (i.e. countrywide) scheme: farmers from any part of the country can apply, which contrasts with the programmes in certain other Member States which have adopted a 'zonal' approach, focusing on certain areas. Farmers who wish to join the scheme must do so for five years, and must apply the scheme's measures to the entirety of their farm. An agri-environment plan is then drawn up for the farm by an approved planner. Over 35% of Ireland's farmers have joined the scheme, covering an area of more than 1.5 million hectares.

The scheme consists of 11 measures, and a further 6 ‘Supplementary Measures’. Measures relate to waste management, grassland management, protection of watercourses, retention of wildlife habitats, maintenance of field boundaries, restrictions on the use of herbicides, pesticides and fertilisers near hedgerows, lakes and streams, protection of archaeological features, visual appearance of the farm, production of tillage crops in a prescribed fashion, attendance at a training course and the keeping of appropriate records.

Several REPS measures are of particular relevance to the biodiversity of wild flora and fauna living on farms. They are as follows (Department of Agriculture and Food 1999):

Measure 3 - Protect and maintain watercourses and wells

Under this measure, streamside vegetation must be fenced off and allowed to develop.

Measure 4 – Retain wildlife habitats

This measure is intended to facilitate the retention of habitats listed in the measure, and to ‘curtail commercial farming practices on these areas in the interests of wildlife’.

Measure 5 - Maintain farm and field boundaries

This measure specifies guidelines for hedgerow maintenance and protection.

Measure 6 - Cease using herbicides, pesticides and fertilisers in and around hedgerows, ponds and streams

A spray limit of 1.5m of the aforementioned features is specified.

Measure 9 - Tillage crop production

One of the requirements of this measure is that an uncultivated strip of at least 1.5m be retained at the margin of the field.

The importance of monitoring and evaluation

Monitoring and evaluation is important for several reasons, including the following.

- The world’s living resources are being depleted all the time. If sustainable development is to be a realistic objective, we need to monitor change in those living resources as a basis for modelling strategies of such sustainable development.
- Without monitoring changes in natural communities, in the status of species and habitats, we have little on which to base good policies and practices. In evaluation and refinement of a policy or scheme, there is no substitute for a system of ongoing monitoring, with baseline data to provide a basis for comparison.
- The quality of water, air and soil can be monitored using indicator species and indicator communities far more successfully than by chemical monitoring alone.
- Long-term ecological studies are rarely conducted, and biological monitoring programmes have an important role to play in developing our understanding of natural long-term processes of ecosystems, and in providing essential baseline data.

Although the REPS is subject to several ‘point assessments’ examining aspects of its ecological impact, there is no system of ongoing monitoring in place. Furthermore, there is a failure to define specific targets. Without targets and quantified objectives it is difficult to relate the results of evaluation back to the scheme. There is concern that the failure of most EU Member States to define performance targets for their agri-environmental schemes, may mean that performance against objectives will not be properly

assessed. The REPS and its sister programmes elsewhere are innovative schemes which will need to be appraised and modified if they are to realise their full potential (Hamell 1999). Monitoring and the definition of quantified targets are fundamental to effective appraisal. Agri-environment schemes must earn their keep: benefits yielded must be self-evident and quantifiable, or their future becomes uncertain.

Agri-biodiversity species indicators have the potential to make an important contribution to the monitoring and assessment of the impacts of agricultural practices on wild flora and fauna on agricultural land. Such indicators have a role to play in the establishment of appropriate policies and in providing an early warning system for the deterioration of key communities and habitats.

In contrast with the UK, which has a highly advanced monitoring infrastructure in the form of the UK Breeding Birds Survey and the Butterfly Monitoring Scheme, Ireland's nature monitoring infrastructure is relatively undeveloped. Ireland does not as yet have the resources in place for large-scale ecological monitoring.

The selection and establishment of baseline data

"Setting baselines is a complex and often an arbitrary process, with many alternative baselines possible" (OECD 2001).

"Care will be required in relating species reductions or increases to agriculture, where other external factors, such as changes in weather etc., may have an effect. Baselines from which to interpret changes in biodiversity are indispensable for valuing the state and trends in biodiversity. The choice, however, is complex" (OECD 1999).

A prerequisite to effective monitoring and evaluation is the presence of a basis for comparison, a benchmark against which trends can be measured, or an agreed target level to be aimed for. Without baseline data to provide this basis for comparison, a set of monitoring data are merely a list of observations, rather than a tool for policy assessment and evaluation. Furthermore, baseline data are an integral element in the development of indicators: "Defining baselines is an important step in calibrating, comparing and interpreting indicators of biodiversity" (OECD 2001).

Considerable confusion has arisen over what is meant by 'baseline'. It is quite common for a baseline to be described on the basis of a one-off survey, which really only provides a snapshot of current conditions. Ecosystems are dynamic and it is essential to take account of their inherent spatial and temporal variation if any attempts are to be made to attribute subsequent changes in ecosystem parameters to specific stresses or actions (Trewick 1999). Many systems have 'moving baselines' which may not be adequately characterised by a short run of data alone. A true baseline study is necessarily based on comprehensive monitoring. Moreover, the baseline must be set according to the same methodology employed in subsequent monitoring, necessitating the establishment of a standard protocol.

Standard protocols have been established for monitoring certain groups. For example, in Northern Ireland the Centre for Environmental Data and Recording (CEDaR), established by the Ulster Museum in 1995, serves as a local records centre and produces atlases on certain key groups (eg. The Ground Beetles of Northern Ireland. Atlases of the Northern Ireland Flora and Fauna no. 1. Anderson et al., 2000). CEDaR is responsive to the local conditions and needs of the environmental recording community. Also in Northern Ireland, the Environmentally Sensitive Areas (ESA) Scheme has been monitored since the early 1990s by systematic flora surveys and the collection of ground predators by standardised pitfall trapping in Scheme areas. This ongoing monitoring has generated a valuable, detailed database of flora and

Carabidae (ground beetle) fauna distributions and populations around Northern Ireland. It is likely that a Biological Record Centre will be established in Ireland in response to the forthcoming Biodiversity Action Plan, and it is hoped that this Centre will be modelled on the precedent set by CEDaR.

Another example of the establishment of a standard monitoring protocol is the development by the four Nordic countries of co-ordinated, standardised monitoring guidelines for terrestrial species and habitat diversity (From and Söderman 1997). These valuable guidelines cover a wide range of groups – lichens, bumblebees, bats – as well as those groups such as birds and higher plants which normally receive greatest attention. In the UK, the well-established Butterfly Monitoring Scheme and the national Breeding Bird Survey have been carried out using consistent methods over a long period of time, providing both a valuable baseline for evaluating subsequent changes, and a ready-made framework for indicator selection and monitoring.

The Environmental Indicators for Agriculture document (OECD 2001) states that many alternative baselines are possible with respect to wild species. These include setting the baseline at the time of the CBD's agreement in 1992, determining a baseline that represents the 'natural state', or establishing a baseline prior to the intensive use of inputs in agriculture, which for many OECD countries is around the 1950s. Because of the need to establish a baseline according to the same, standardised methodology used to conduct monitoring thereafter, ensuring that the baseline provides a meaningful basis for comparison, these three options will rarely be practical or possible. In all three cases, there are many other factors which can not be controlled for, and which prevent a direct comparison from being made with current levels of biodiversity.

An alternative is to set the baseline at the onset of the new wave of monitoring for which this OECD work is laying the foundations. In Ireland there are no long-term datasets that can be called upon to provide baseline data or from which potential indicator species can be selected. Therefore, the baseline should be defined as the situation at the onset of monitoring. Although this does not co-incide with the instigation of the CBD, or with the inception of the REPS in 1994, it is at least reliable and defined according to a standardised methodology. What the indicators are indicating will be clear. Deterioration or improvement will be related to known conditions.

Developing a baseline *de novo* is a challenge for Ireland and those other countries with little or no tradition of nature monitoring from which to draw. This, however, is accompanied by the advantage that the design of effective and appropriate monitoring strategies will not be 'data led'. There will not be the obligation to give undue emphasis to certain groups for the sake of continuity and convenience, rather than scientific justification and rigorous evaluation of their potential as indicators. For example, birds are frequently picked out to serve as indicators primarily because they are such a well-known, thoroughly-monitored group rather than for their indicator value *per se*: their selection is often 'data led'. In regions where there is no such outstandingly well-studied group, other more objective criteria can come to the fore in indicator group selection. These criteria are discussed below.

The selection of VECs (Valued Ecosystem Components) and indicator species

"Indicators of wildlife species diversity related to agriculture: Appropriate key species indicators for each agro-ecosystem". "The choice of species (possibly surrogate species, taxonomic groups or Red List endangered species) would be left to individual countries" (OECD 1999).

"Indicators for species diversity cover trends in population distributions and numbers of a) wild species dependent and/or affected by agriculture, and b) non-native species threatening agricultural production" (OECD 2001).

Effective biodiversity indicators of necessity have high spatial resolution: they are of little value without reference to the spatial context. As described above, "appropriate ... indicators for each agro-ecosystem" will be needed: a species that is a useful indicator in one particular area will be absent from other areas, or so common as to be insensitive to management change and habitat fluctuations. The diversity of landscapes and habitats within a region, not to mention the diversity of soil types within one farm, mean that national level quantification is highly problematic (OECD 1999). Clearly, it is not possible to employ the same species indicators in different countries and ecosystems.

As the recent Environmental Indicators for Agriculture document (OECD 2001) details, different countries have different approaches to assessing and monitoring wild species populations. There is wide variation in availability of data and in the level of biodiversity research. Moreover, most OECD countries do not have a specific monitoring system to track wild species populations and numbers on agricultural land (OECD 2001). However, despite the diversity of approaches that have been taken in different countries, and despite the fact that different species indicators must be defined in different ecosystems and habitats, it is imperative that some level of standardisation be achieved between countries with regard to the monitoring of wild species agri-biodiversity. There are certain guidelines that should be adhered to if indicators are to be defined according to sound criteria.

The need for an objective and transparent approach to indicator selection

The species richness of agricultural areas may rank in the order of tens of thousands of species. The need to restrict the range of surveyed components has resulted in the development of focusing procedures to select suitable 'valued ecosystem components' (VECs) to provide the focal point for ecological impact assessment. Focusing procedures are not always formalised, and this aspect of impact assessment is fraught with difficulties. Ideally, VECs are selected according to criteria that are objective, consistent, transparent and defensible. VECs encompass habitat and ecosystem characteristics as well as individual species of interest. It is the wild species indicators that emerge from these focusing procedures that are examined in this paper.

Here the procedures according to which wild species which are potentially useful as VECs, and indeed as indicators, are selected will be considered.

OECD countries have applied different approaches to describe and assess the state and trends in population distribution and numbers of wild species associated with agriculture. Wide variation in the availability of data, differing stages of scientific research and varying policy priorities make the development of a consistent method of calculation extremely difficult. Amidst this patchy availability of data, there is a danger that VECs or ecological indicator species may be selected by two processes that rarely rely on scientific criteria (Pearson 1994). First, rare taxa often become indicators by default. Public pressure may focus on the taxon itself, rather than what it purports to indicate, for example habitat degradation, ecosystem decline and species distribution patterns. Second, some taxa have been defined as indicators solely because they are well-studied and familiar, the taxonomic favourite of the in-house ecologists. Expedience alone is insufficient justification for the selection of an indicator taxon: if indicators are to be meaningful, their selection must be more rigorous and transparent.

Key criteria for the selection of indicator taxa

A number of useful criteria that can be used to objectively test the claim that a given taxon is an ideal indicator or VEC are discussed below (after Pearson 1994, Brown 1991). These criteria are:

- ‘Surrogate value’: patterns of biodiversity reflected in other related and unrelated taxa
- Higher taxa broadly distributed geographically and over a breadth of habitat types, lower taxa specialised and sensitive to habitat change
- Well-known and stable taxonomy, well-known natural history
- Readily surveyed and manipulated
- Potential economic importance

‘Surrogate value’: patterns of biodiversity reflected in other related and unrelated taxa

Selected species should, by their presence alone, reveal useful information about the habitat and the species assemblage with which they are associated. A taxon which consistently occurs in association with certain other species (an 'umbrella species') is potentially useful in indicator development. Such 'surrogate taxa' may serve as useful proxies of biodiversity quality (OECD 1999, another reference). A guild is a group of species that exploit the same class of resources in a similar way, and the selection of 'guild indicator species' is a useful approach because it allows the assessment of habitat resources as well as species population. For endangered species, there is a risk that indirect monitoring using a guild indicator or surrogate species may jeopardise status, and so such species should be monitored directly.

Higher taxa broadly distributed geographically and over a breadth of habitat types, lower taxa specialised and sensitive to habitat change

Species (lower taxa) which are known to be susceptible to habitat change and which are highly responsive to defined impacts may serve as a useful 'early warning' for a wider community. Comparisons can more readily be made between studies conducted in different locations if the higher taxa (genera, families) are broadly distributed geographically and over a breadth of habitat types (Pearson 1994).

Well-known and stable taxonomy, well-known natural history

Taxonomic stability and reliability is a prerequisite for any indicator taxon: identification must be relatively straightforward, not requiring a high level of expertise. Clearly, the natural history of the taxon must be well researched in advance in order to maintain a sense of ecological context at all times. Extensive natural history knowledge is necessary for the adoption of for example the 'guild indicator' approach: a considerable amount of information is needed to establish the presence of guilds in an area and to estimate the significance of difference between guild members. The concept can only be used for species that have been well studied and for which detailed autecological information is available (Treweek 1999).

Readily surveyed and manipulated

In the event, the most mundane and practical reasons can lead to the selection of a particular group for targeted sampling. An otherwise ideal indicator taxon may require a highly labour-intensive sampling strategy for which the resources may not be available. Butterfly and dragonfly surveys, for example, require many repeated visits to the same sites in the same weather conditions. Groups that are sampled

using sweep-netting (eg. Heteroptera, see example below) can only be surveyed when vegetation is dry. This is a problem in a wet country like Ireland! Pitfall trapping does not present this particular difficulty.

Species selected as indicators should be those for which follow-up monitoring is a realistic option. One-off surveys alone are of little predictive value and do not contribute to the overall knowledge base. Selected species will need to be readily surveyed in a standardisable manner on an ongoing basis. The importance of standardising techniques cannot be over-emphasised (Stork and Davies 1996). Where consistent, standardised survey methods are used there is considerably more scope for comparative analysis.

Potential economic importance

Evidence that populations of certain species are of economic importance can help to convince scientists and politicians that it is worth dedicating local personnel and resources to the study of those species. This is particularly the case in developing countries where pure of basic science is frequently considered a luxury (Pearson 1994).

Monitoring studies evaluate changes in habitats or ecosystems over time, such as habitat degeneration. In this case, high priority for potential indicators is placed on sensitivity to environmental change. Priority assigned to indicator criteria will vary depending on whether it is a monitoring study or an inventory study that is being undertaken. Pearson's (1994) suggested prioritisation for monitoring studies is as follows:

1. Economic potential
2. Occurs over a broad geographical range
3. Patterns of response reflected in other taxa – ‘surrogate value’
4. Biology and natural history well-known, taxonomy stable
5. Easily observed and manipulated
6. Specialisation to habitat.

An example of indicator taxon selection is the study by Di Giulio *et al* (2001) on the enhancement of insect diversity in agricultural grasslands. The true bugs (Heteroptera) were chosen as an indicator group for insect diversity on the basis of the following criteria:

- They are an ecologically very diverse group, including phytophagous saprophagous and predatory species
- Some species are generalists while others are specialists
- Both larval and adult stages live in the same habitat and respond sensitively to environmental changes
- Previous studies have shown that the richness of the bug fauna correlates strongly with total insect diversity
- Despite their ecological diversity, the Heteroptera is a manageable group in terms of the numbers of species occurring in grasslands.

Assessing the impact of the REPS on plant and invertebrate species diversity on farmland: an example of agri-biodiversity monitoring and indicator selection

In order to illustrate the kind of fieldwork that agri-biodiversity monitoring necessitates, an outline of my research methodology is given below. The fieldwork protocol reflects in a practical way some of the constraints that differentiate between theory and practice. This research is being undertaken as part of a Ph.D. funded by Teagasc, the Irish agriculture and food development authority.

The study assesses the impact of the REPS on plant and invertebrate species. Measures relating to the management of field margins, watercourse margins and hedgerows (measures 3, 6 and 9) were examined. Two farming systems, drystock grassland and tillage, were studied. These were selected in order to reflect the generality of REPS farms: the majority of REPS farms are grassland, with tillage being the second highest farm management type in the Scheme. Special Areas of Conservation (SACs) were avoided, as were areas of particularly high nature-value, again in order to conserve the relevance of the study to the ordinary farmland that comprises the majority of farmland within REPS.

Focusing procedures were employed to select groups for sampling, and a standardised protocol for the evaluation of these groups was established. Habitat types and indicator species for those habitats are now being identified from the data. These indicator species will be highlighted thereafter because they are disproportionately informative, and are useful as 'cases in point' in describing the effects that the scheme is having. This approach is modelled on the monitoring methodology employed in Northern Ireland in the ongoing ESA (Environmentally Sensitive Area) scheme evaluation (Anderson *et al.* 2000).

Methods

Indicator group selection

Two taxa, plants and Carabidae or ground beetles, were selected for sampling. Both groups fulfil many of the criteria for indicator group selection discussed earlier.

Higher plants are the mainstay of many monitoring and assessment studies: they are the primary producers and most habitats are characterised according to floral composition. Plant diversity can act as a surrogate for the diversity of other taxa because many species in a community are specifically adapted to the presence of host plant species (Begon *et al.* 1996, Spellerberg 1995). Plants were surveyed using quadrats in field margins. A hierarchical sampling design enhanced sensitivity to community change.

The Carabidae were selected as an invertebrate indicator group. Broadly distributed geographically and across a wide range of habitats, the group features several guilds including herbivores, predators and scavengers. Some species are widely-distributed generalists while others feature highly specific habitat requirements; their potential contribution to the assessment of environmental threat and pollution must be regarded as significant (Forsythe 1996, Anderson *et al.* 2000). Carabids were surveyed using pitfall traps. This standardisable, widely-used technique yields large amounts of data per unit effort compared to other invertebrate sampling methods such as butterfly surveying, which is highly labour-intensive. Pitfall trapping is biased towards the most active surface-movers, rather than the most abundant, and other techniques such as sweep-netting and D-vac sampling may avoid this bias (Southwood and Henderson 2000). These, however, require perfectly dry conditions and collect many juveniles, which are difficult to identify.

Fieldwork

Fieldwork was carried out during 1999 and 2000. 60 farms in three counties were surveyed, 30 of which were REPS farms and 30 non-REPS farms. During 1999, cattle-grazed grassland in Laois and Offaly was surveyed, and during 2000 tillage land in Wexford was surveyed (Table 1). Farms were selected by random selection from a list of suitable farms. Only REPS farms which had been in the scheme for at least four years were selected. This was necessary to optimise the likelihood of detecting any impact that the scheme may be having.

Table 1. Breakdown of the 60 farms surveyed during the study

County	Farm type	REPS farms	Non-REPS farms	Year sampled	Total
Laois	Grassland	7	7	1999	14
Offaly	Grassland	8	8	1999	16
Wexford	Tillage	15	15	2000	30

Plants

On each farm two hedgerows, their associated field margins and one watercourse margin were surveyed. Each of these components was, wherever possible, selected randomly. Field and watercourse margins were surveyed using a nested quadrat system incorporating both percentage cover and species presence data (Cameron *et al.* 1997). Recording at a range of scales in this way maximises the likelihood of detecting changes in the abundance of a wide range of species (Critchley 1997). The boundary area 1.5m from the hedge or the watercourse was surveyed separately from the next 1.5m band out from that, thereby enabling assessment of the impact on plant diversity of measures designed to eliminate inputs in field margins and alongside watercourses.

Carabidae (Ground Beetles)

Carabids were recorded using pitfall traps. Trapping was done in early June and late August. On each trapping occasion two pitfall traps 10m apart were set in each of the two plant-surveyed field margins, yielding a total of 8 traps per farm. Traps were left in place for two weeks. Beetles were identified to species using Lindroth (1996) and Forsythe (1996).

Environmental variables

The environmental variables that were recorded from each site included hedge height, gappiness, approximate age of the hedge, aspect, an outline of the management history of the field, age of watercourse fence and proximity to large non-farmland habitats such as forests, bogland or lakes. Soil samples were taken from all the plant relevée sites, both from the inside 1.5m strip and the outside 1.5m strip. Basic nutrient analysis was carried out on the samples. A brief questionnaire was administered to ascertain details about management of the surveyed fields, to ask farmers what they thought of the scheme

and - in the case of REPS farmers - to investigate the changes that the scheme has necessitated on their particular farm.

Data analysis: statistical methods used to select indicator species from a dataset

Two-Way Indicator Species Analysis (TWINSPAN) is a widely-used analytical technique for examining species assemblages and pinpointing species which indicate the presence of assemblages of interest (Kent and Coker 1992). The analysis involves the construction of ordered two-way species/sites tables. This is done at a series of levels, where the data are divided into paired groups. The groups are further subdivided until the operator perceives that the end groups correspond with the different communities observed. To each division, and to each of the final assemblages, at least one indicator species is assigned.

In the ground beetle dataset, one of these 'final assemblages' is a group of species that are characteristic of well-established woodland. The presence of these species in hedgerows can be interpreted as an indication that the hedgerow is likely to be particularly ancient. The indicator species that is assigned to this assemblage is *Cychrus caraboides*, a large distinctive beetle with characteristically elongated mouthparts that are adapted for consuming snails. It is, in other words, very easily identified by a non-expert. In the plant dataset, common cleavers (*Galium aparine*) and nettles (*Urtica dioica*) have been identified as indicators of soils that are particularly rich in nutrients such as phosphorous.

In the monitoring of the Northern Ireland ESAs, the two species *Carabus nitens* and *Nebria salina* were found to be particularly characteristic of the community that favours open conditions in upland heaths including mountain summits. These two species are therefore indicators of that particular ecosystem.

Relating indicators to changes in agricultural practices

"For policy makers, it is very important to be clear about the precise linkage of any indicator to agricultural practices. A number of indicators have been developed which are not very sector-specific, in the sense that agriculture's contribution to the harm and/or benefit of the environment cannot be separated from other economic sectors. This makes it difficult to interpret the agricultural policy implications of the indicators" (OECD 1999).

Relating indicators to changes in agricultural practices is very important if they are to be policy-relevant. In my work, this linkage is achieved by carrying out fieldwork which related directly to specific measures within the Scheme, and carrying out the same procedures on areas which are not subject to those measures.

For example, REPS tillage farmers are asked to leave an uncultivated margin of at least 1.5m in all tilled fields, and to eliminate chemical inputs in this margin area. The width of these uncultivated margins on 15 REPS and 15 non-REPS farms was measured (in order to assess compliance), and REPS margins were found to be significantly wider. Plant surveys and invertebrate surveys were then carried out in these margins in order to evaluate whether this impacted on flora and fauna in the margins: relating policy to ecology. A second measure requires the fencing of watercourse margins where livestock are present, and a similar approach was adopted in order to assess the success of this measure in meeting its objective of benefiting riparian flora and fauna.

Conclusions

1. Species indicators have high spatial variation: one habitat's indicator species will not be another habitat's indicator species. However, the same guidelines and criteria should be used to select these indicators across different ecosystems and indeed nations. A common approach should be adopted across OECD countries.
2. Baseline data are fundamental to any monitoring strategy. The most recent Environmental Indicators for Agriculture document (OECD 2001) cites several possible baselines. These include setting the baseline at the time of the CBD's agreement in 1992, determining a baseline that represents the 'natural state', or establishing a baseline prior to the intensive use of inputs in agriculture. However, baseline data must be collected according to the same methodology employed in ensuing monitoring. Thus, the most reliable basis for comparison will usually simply be the situation at the onset of monitoring.
3. The steps towards species indicator selection (focusing procedures) can be summarised as:
 - Theoretical criteria including 'surrogate value' as discussed in the 1999 Environmental Indicators for Agriculture document (OECD 1999), where patterns of diversity are reflected in other taxa. Other criteria, discussed here, include the wide distribution of higher taxa, specialisation and sensitivity to habitat change of lower taxa (species), well-known and stable taxonomy and thoroughly researched natural history.
 - Practical considerations concerning fieldwork methodology. For example, target groups must be easily handled and identified, and survey methods must be standardisable between different regions.
 - The selection of indicator species from data, using statistical tools such as Twinspan (Two-Way Indicator Species Analysis).
4. Amidst patchy availability of data, there is a danger that ecological indicator species may be selected by two processes that rarely rely on scientific criteria. First, rare taxa often become indicators by default. Second, some taxa have been defined as indicators solely because they are well-studied and familiar. Expedience alone is insufficient justification for the selection of an indicator taxon: if indicators are to be meaningful, their selection must be more rigorous and transparent.
5. Ireland, like many other countries, is a relatively blank canvas in terms of baseline data availability, monitoring development and species indicator selection. This means that indicator development can proceed in an unbiassed manner, not 'data-led' but rather 'problem-led'.

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