(Greig-Smith & Hardy, 1992), its relatively poor returns do not give a general indication of the potential economic benefit of integrated farming.

The Boxworth project highlighted some of the problems that can arise when managing reduced-input systems. These included: (1) the difficulty in keeping long-term pesticide regimes realistic under controlled experimental conditions (Greig-Smith & Griffin, 1992), (2) the difficultly of investigating simultaneously economic, agronomic and environmental factors because of compromises in scale *vs* replication (Greig-Smith & Griffin, 1992) and (3) a failure to reduce the incidence of cereal diseases in an integrated regime by using cultivar mixtures (Yarham & Symonds, 1992).

Other information

The environmental and economic studies within the Boxworth project were valuable components but the restrictions imposed on economic studies by the demands of the environmental work suggested that subsequent studies would be better divided into those driven primarily by environmental concerns and those dictated by economic priorities. As a consequence, different experimental approaches are now being used in two follow-up studies to Boxworth, the environmentally-driven SCARAB project and the economically-driven TALISMAN project (Cooper, 1990), which are described below.

The Boxworth project was not extended further in its original format on completion in 1988, mainly because the full insurance programme was unrepresentative of the then farming practice. Instead, it was continued in a limited form for a further three years to assess the potential for recovery of arthropod populations once the high-input full insurance regime was replaced by a lower-input supervised programme. This work showed that ground beetles, spiders and springtails recovered from the full insurance regime very slowly, indicating that effects of intensive pesticide use in cereals can last for years even after the intensity of pesticide use is reduced; recent European work has also shown persistent effects of pesticide use in other high-pesticide-input crops (e.g. hop gardens and vineyards; Filser, Fromm, Nagel & Winter, 1994).

SCARAB (Seeking Confirmation About Results At Boxworth) (1989–1996)

Background

SCARAB was set up to investigate whether the results obtained from the Boxworth project could occur more widely, at other locations, with different soil types, in a wider variety of arable crops and with typical 1990's pesticide inputs. The project is one of two follow-up studies to the Boxworth project; SCARAB is primarily an environmental study with subsidiary economic and agronomic monitoring while TALISMAN (described below) is primarily concerned with economic and agronomic aspects of reducing pesticide inputs, with environmental monitoring having a subsidiary role. These two projects and RISC (also described below) are designed to complement one another. SCARAB is funded by MAFF and is being undertaken in collaboration with a number of research organisations. Its primary aim is to compare the long-term effects of two pesticide regimes; these are conventional and reduced pesticide input systems. SCARAB is concerned only with pesticide use; fertiliser inputs and other components of integrated farming systems are examined in some of the other studies described below.

Design and methods

The two pesticide regimes are a 'current farm practice' (CFP) and 'reduced input approach' (RIA). CFP is based on the current pesticide use for the location (based on survey reports) as carried out by a technically competent, financially aware farmer and will accommodate any year-to-year changes in agricultural practice. RIA is based on the minimal use of fungicides and herbicides determined by crop monitoring and the use of thresholds. Insecticides are avoided completely unless major crop losses are anticipated. SCARAB has seven fields, ranging from 8 to 34 ha, located at three Agricultural Development and Advisory Service (ADAS) Research Centres in England: Drayton (Warwickshire), Gleadthorpe (Nottinghamshire) and High Mowthorpe (North Yorkshire) (Cooper, 1990). Cropping at each location follows a six- or seven-year rotation which is typical of the region. At Drayton Research Centre the rotation is two wheats and five years' grass ley whilst at Gleadthorpe and High Mowthorpe Research Centres a six-course rotation is followed consisting of cereals and break crops (potatoes, spring beans and sugar beet (Gleadthorpe); spring beans and winter oilseed rape (High Mowthorpe)). In the first, "baseline", year of the project all the fields received a CFP regime appropriate for the crop to allow invertebrates to be monitored in the absence of contrasting treatments. Since the autumn of 1990 one half of each field has received an appropriate RIA regime whilst the other half has continued to receive CFP pesticide inputs. Cropping, fertilisers and cultivations do not differ between the CFP and RIA halves. At each Research Centre the appropriate rotation is phased by starting it at a different crop in each field; this is to make information on all crops available sooner than the full six years that would be needed if all fields entered the rotation at the same point. However, unlike the economically-orientated TALISMAN and RISC projects which also have phased rotations (see below), the SCARAB CFP and RIA regimes are not strictly replicated as the two or three split fields per site are at different rotational phases and subsequently each field receives different pesticides during a growing season. Justification for this type of design is based on the premise that long-term monitoring should, as in the Boxworth project (Greig-Smith *et al.*, 1992), detect effects of the regimes on invertebrates.

The emphasis of the research in the SCARAB project (Table 4) is on monitoring the effects of the pesticide regimes on invertebrates and soil micro-biology. Populations of arthropods have been monitored since the start of the project by entomologists at Southampton University using pitfall traps and suction samples (Frampton & Çilgi, 1992, 1993, 1994) and MAFF researchers have been monitoring earthworm populations. Soil micro-biology and chemical composition are routinely analysed in selected fields by micro-biologists at University of Wales, Bangor (Jones, Jones & Johnson, 1993). The distribution and abundance of pests, weeds and diseases are examined by researchers at each of the Research Centres to monitor them in relation to control thresholds; crop yield and quality are recorded for the subsidiary economic appraisal.

Principal results

Preliminary results indicate that current (CFP) pesticide use in UK arable crops is environmentally more damaging than using reduced inputs (RIA). Although the project was designed to study the overall long-term effects of the CFP and RIA regimes rather than those of specific pesticide applications, some individual broad-spectrum insecticides have caused obvious reductions in catches of some Carabidae (ground beetles), Staphylinidae (rove beetles), Linyphiidae (money spiders) and Collembola (springtails). Temporary elimination of several species of Carabidae and Collembola occurred, particularly after applications of chlorpyrifos and dimethoate (Çilgi, Wratten, Frampton & Holland, 1993; Frampton & Çilgi, 1994); populations of some species of Collembola did not recover within 18 months of a pesticide application and these results show that they could be valuable indicators of non-target pesticide effects (Frampton, 1994). The severity of pesticide effects has varied between years, species, crops and locations and it would be premature to draw any firm conclusions until the full range of crop-site-species-pesticide combinations has occurred. However, already it is clear that persistent adverse effects of pesticides, like those seen at Boxworth, can occur with conventional 1990's pesticide inputs and that adverse effects of conventional pesticide use may occur in other arable crops besides cereals.

Overall, soil biomass levels were similar under the two regimes, but some transient effects of soil type and short-term pesticide use were found. At High Mowthorpe Research Centre, applications of herbicides (bentazone and glyphosate) and fungicides (metalaxyl and chlorothalonil) produced a temporary stimulation of soil biomass, whereas the insecticide pirimicarb significantly reduced total and fungal biomass. At Gleadthorpe Research Centre the sandy loam soil produced more variable results and individual pesticide effects could not be ascertained (Jones *et al.*, 1993).

Weed monitoring up to 1992 indicated that, compared with the CFP herbicide use, the efficiency of the half-rate RIA herbicide treatments varied from very effective to inadequate. Weed control tended to be poorer in broad-leaved crops (oilseed rape and beans) than in cereals (Ogilvy, Green, Groves & Jones, 1993). Although SCARAB is not concerned primarily with low inputs of herbicides, monitoring weeds could be a valuable aid to interpretation of the results of invertebrate monitoring as the presence of weeds may affect the activity and distribution of non-target arthropods (Speight & Lawton, 1976).

In the first two years after implementing CFP, yields exceeded those of RIA for the majority of crops although differences were sometimes small. Where variable inputs were lower for the RIA compared to the CFP regime, higher gross margins were achieved.

To draw firm conclusions from these results would be premature as they represent only two years' monitoring. However, it is clear that whilst CFP regimes often gave the best financial returns, the RIA treatment can economically out-perform CFP under certain cropping situations.

Other information

The designs of the Boxworth and SCARAB projects are compared in Çilgi *et al.* (1993) and Frampton & Çilgi (1993).

TALISMAN (1989–1996)
(Towards A Low Input System Minimising Agrochemicals and Nitrogen)

Background

TALISMAN is the second long-term MAFF study that was set up to extend the information obtained from the Boxworth project to a wider range of crops, soils, locations and to typical current agrochemical inputs. Its main objective is to measure the economic and agronomic effects of implementing cropping systems with lower agrochemical and nitrogen inputs than conventional farming systems. It also aims to provide information on the scale of compensation necessary to attract farmers to adopt such lower-input systems. Environmental monitoring forms a subsidiary part of the project. In these respects TALISMAN is very similar to, and complements, the RISC project which is sited in Northern Ireland and is described in detail below.

Design and methods

The experiment was initially located at four ADAS Research Centres in England. Three of these are shared with the SCARAB project and the fourth is at Boxworth in Cambridgeshire. After harvest 1991, the Gleadthorpe TALISMAN site was discontinued due to unpredictable variation in soil but preliminary results from that site have been published (e.g. Clarke *et al.*, 1993).

At all TALISMAN sites there are two farming systems: "Current Commercial Practice" (CCP) and "Low Input Approach" (LIA); and two six-course rotations: "standard" and "alternative" (Table 6*a*). The standard rotation consists of winter sown cereals and break crops whilst the alternative rotation comprises mainly spring-sown cereals and break crops which have a lower requirement for nitrogen and pesticides (Clarke *et al.*, 1993). The CCP system represents typical current nitrogen and pesticide inputs and uses the ADAS "Fertiplan" fertiliser planning service (Goodlass, 1991) to determine nitrogen use. The LIA is a low nitrogen and pesticide input system in which nitrogen is applied at 50% of the CCP rate. CCP pesticide use is based on current ADAS thresholds in conjunction with field monitoring, with widely-used products applied at full recommended rates. The priority in the LIA is to not apply pesticides unless a yield loss of more than 10% is expected, in which case up to 50% of the recommended rate may be applied. An additional farming system, "Integrated Low Input Approach" (ILIA), in which cultural measures such as different cultivations, sowing dates and cover crops are used to reduce the impact of lower nitrogen and pesticide use, is also employed at one of the TALISMAN sites (Table 6*a*).

At each site the rotations were phased by starting them respectively in the first (phase 1) and fourth (phase 2) crops of the sequence to take some account of the effects of seasonality and provide information on all crops after three rather than six years. Altogether there are 10 treatments comprising different combinations of the farming systems, the rotations and their phases (Table 6*a*). Six of the treatments are common to all four TALISMAN sites and form the main experimental comparisons; the additional four treatments are limited to one or two of the TALISMAN sites but are complemented by very similar treatments at two sites in Northern Ireland as a component of the RISC project (Table 6*a*).

The economic and, secondarily, environmental effects of the TALISMAN treatments are being compared using replicated plots of a minimum size of 18 m × 20 m, with rotation and farming system as the main treatments. Interactions between the CCP and the LIA rates of herbicides, fungicides and insecticides are examined in addition to the main treatments by using sub-treatments (Table 6*b*) by dividing each main plot into five equal sub-plots. At each site the plots are arranged within a field in a randomised block design with 12 m-wide mown grass strips separating the plots; there are three replicates of each treatment at three of the sites and four at Boxworth. This allows a rigorous statistical appraisal of the economic consequences of reducing pesticide and nitrogen inputs and has the advantage of examining these regimes in homogenous blocks of land duplicated in localities with different soil types.

Agronomic monitoring (Table 4) in the sub-plots includes assessments of the incidence of weeds, pests, and diseases in conjunction with crop morphology, yield, quality and economic gross margins. Plant seedbanks and soil nematode populations have also been monitored in selected plots since the spring of 1991 by researchers at the Scottish Crop Research Institute. An additional block of plots adjacent to a field boundary is used at each site solely for assessing effects of the main treatments on arthropods. These plots, which are not sub-divided but are otherwise identical to others at the site, are sampled routinely using pitfall traps and suction samplers.

Principal results

In 25 comparisons between the CCP and the LIA made up to 1992, the LIA gave measurable yield losses on 12 occasions but only four of these were greater than 5%. Gross margins were lower in the LIA than the CCP on seven occasions, but differences were mostly very small (Clarke *et al.*, 1993).

High weed infestations in some LIA crops illustrated the potential longer-term problems

Table 6(*a*). *Summary of treatments in TALISMAN and RISC projects*

				TALISMAN sites				RISC sites	
Treatment	Rotation	Phase	System/Regime	Boxworth	Gleadthorpe	Drayton	High Mowthorpe	Hillsborough	Greenmount
1	Standard	1	CFP/CCP	Yes	Yes	Yes	Yes	Yes	Yes
2	Standard	1	LIA	Yes	Yes	Yes	Yes	Yes	Yes
3	Standard	2	CFP/CCP	Yes	Yes	Yes	Yes	Yes	Yes
4	Standard	2	LIA	Yes	Yes	Yes	Yes	Yes	Yes
5	Alternative	1	CFP/CCP	Yes	Yes	Yes	Yes	Yes	Yes
6	Alternative	1	LIA	Yes	Yes	Yes	Yes	Yes	Yes
7	Alternative	2	CFP/CCP			Yes	Yes	Yes	Yes
8	Alternative	2	LIA			Yes	Yes	Yes	Yes
9	Standard	2	INT/ILIA					Yes	Yes
10	Alternative	2	INT/ILIA					Yes	Yes
11	Standard	2	MIN					Yes	Yes
12	Alternative	2	MIN					Yes	Yes

CFP = conventional farm practice, CCP = current commercial practice, LIA = low input approach, ILIA & INT = Integrated Low Input Approach, MIN = Minimum Inputs.

Table 6(*b*). *Sub-plot treatments used in TALISMAN and RISC*

Sub-plot	Fungicide	Herbicide	Insecticide
1	CFP/CCP	CFP/CCP	CFP/CCP
2	LIA	LIA	LIA
3	LIA	CFP/CCP	CFP/CCP
4	CFP/CCP	LIA	CFP/CCP
5	CFP/CCP	CFP/CCP	LIA

that can arise if herbicide inputs are reduced. Monitoring weed seeds revealed that plots at Boxworth that had previously been sown with oilseed rape had higher densities of *Brassica* seeds in the soil, whilst plots previously under linseed had higher densities of *Poa* seeds. The long-term implications of these results are not known but they demonstrate that an accumulation of weed populations in the seed bank may be difficult to avoid unless the correct combination of cropping and herbicides is achieved. So far, no other effects of the treatments on weed seeds have been detected.

Preliminary results for the range of pesticides tested in TALISMAN suggest that reducing the rates of many pesticides can give significant savings (Bowerman, 1993), although this is likely to be achieved less easily in broad-leaved break crops than in cereals.

Preliminary results of arthropod monitoring have shown effects of individual pesticide applications on some Carabidae, Arachnida and Collembola but it is difficult to judge the importance of these because catches have also shown considerable variation in the absence of pesticide applications (Hancock *et al.*, 1994).

Densities of nematodes at two of the sites were greater where oilseed rape had been sown than where linseed or spring beans were grown, perhaps reflecting an effect of continuous over-winter vegetation cover. Some apparently detrimental effects of full-rate applications of nitrogen and herbicides on predatory nematodes were observed but require verification through continued monitoring.

Other information

As with all small-plot studies TALISMAN has a number of potential limitations; the presence of many crop varieties within a small area could influence the development of disease and pest infestations and could limit the predictive powers of the results, particularly with regard to insect pests and diseases. Some of these potential limitations may be overcome by the "phasing" of the rotations (Cooper, 1990), which gives some temporal as well as spatial replication.

The environmental monitoring (Table 4) is limited to an assessment of invertebrate populations by pitfall sampling and suction sampling in the block of plots adjacent to the field boundary at each site. This should provide an indication of the short-term effects on the more vulnerable species, and provide feedback on those pesticides which might warrant more study in the detailed invertebrate monitoring of the SCARAB project. TALISMAN aims specifically to examine the effects of reducing pesticide and nitrogen inputs and includes the impact of cultural measures only at High Mowthorpe. Other components of an integrated farming systems (IFS) approach are not included, such as the careful management of field margins, which can enhance natural control (El Titi, 1991; Sotherton, 1991).

RISC (Reduced Input Systems of Cropping) (1991–2000)

Background

The RISC project was established and is funded by the Department of Agriculture for

Northern Ireland (DANI) to provide information for Government policy divisions on the scale of compensation necessary to attract farmers to change from current farming systems to those with reduced pesticide and nitrogen use, which are thought to be environmentally more acceptable. RISC will also assess the impact of such changes in husbandry practices on crop yields, farm management and environmental indicators. The aim of the project, like that of TALISMAN (see above), is to measure the economic and agronomic consequences of adopting cropping systems which use lower levels of agrochemicals and nitrogen than conventional cropping systems. RISC is sited in Northern Ireland and was designed to be complementary to TALISMAN in England; the designs of the two projects are similar, with closely matching protocols, but they take account of the different cropping practices and pesticide use in Northern Ireland. RISC, like TALISMAN, concentrates on the *economic* effects of low-input, environmentally benign arable systems, with environmental monitoring of invertebrates of secondary importance.

Design and methods

RISC is sited at two farms and started in 1991 at Hillsborough, County Down and in 1992 at Greenmount, County Antrim. The project is planned to continue until 2000. Two six-course rotations are used: a standard rotation (potatoes, winter wheat, winter barley, oilseed rape, winter wheat, spring barley) and an alternative rotation comprising crops with inherently lower demands for pesticides and nitrogen (two-year grass ley, potatoes, winter wheat, spring barley, winter barley). The cow slurry produced as a by-product of the grass ley enterprise will be used pre-sowing to fertilise the other crops in the alternative rotation. As in TALISMAN, the rotations are phased, by starting them in both the first and fourth crops of the sequence, so that information is available for all crops after three rather than six years.

There are four regimes (Table 6*a*) of pesticide and nitrogen use in the RISC project: (1) Current Farming Practice (CFP) which aims to optimise inputs and maximise productivity using recommended top-yielding varieties. Pesticide use is based on ADAS and DANI surveys and fertiliser use is determined by DANI recommendations, with slurry applied to the alternative rotation; (2) Low Input Approach (LIA) is based on restricted nitrogen and pesticide use and aims to use a maximum of 50% of the overall CFP inputs applied each season (reductions of 50% are not likely to be achieved for every chemical). Pesticides will be omitted unless a yield reduction of more than 10% is anticipated; (3) Integrated Low Input Approach (ILIA) has pesticide and nitrogen inputs no greater than those of LIA but will incorporate other husbandry practices (such as drilling dates, choice of disease-resistant varieties and use of cover crops) in an attempt to reduce the economic and environmental impact of the LIA regime; (4) Minimum Inputs (MIN) is an integrated regime based on the use of slurry or farmyard manure to fertilise crops in the alternative rotation but no fertilisers will be used in the standard rotation except to prevent crop failure. Insecticides will be avoided, and fungicides and herbicides used only as a last resort to secure a viable crop. The policy for the MIN regime may require revision as the project develops. Combinations of the two rotations and four input regimes in the RISC project give a total of 12 treatments, some of which are shared with TALISMAN (Table 6*a*).

The RISC treatments at each site are arranged in a randomised block design with four blocks of plots within a field to give four replicates of each treatment. Plots in one of the blocks near a mature field boundary are large (10 m × 40 m) to allow for invertebrate monitoring using pitfall traps; the remaining three blocks contain plots measuring 10 m × 20 m. In addition to the main treatments, the plots in the latter three blocks are each divided into five sub-plots (10 m × 4 m) to examine interactions between the CFP and the LIA fungicide, herbicide and insecticide inputs (Table 6*b*).

Principal results

As only two years of the project have elapsed it is too early to put a strong emphasis on the results of RISC, especially as the study has been planned to continue for a further eight years. Some time will be required to establish the full significance of the preliminary results summarised here.

The CFP regime gave the lowest gross margins in spring barley, winter barley and one of two oilseed rape crops, but provided both the highest yield and gross margin in potatoes, perhaps reflecting the response of a nitrogen-sensitive crop to the CFP and the LIA differences in fertiliser inputs. In the oilseed rape crop at Hillsborough the low variable costs of MIN helped this treatment to produce the highest gross margin, despite the yield being the lowest of all treatments. Oilseed rape at the Greenmount site exemplified one of the management problems that may occur in a low-input rotation; a serious wild-oat problem led to the decision to forage-harvest the crop to prevent oats seeding and affecting the following crop. Overall, the initial results suggest that a conventional (CFP) farming approach may not always be necessary to achieve the best financial returns, although too few crops have yet been studied in RISC to allow firm conclusions to be drawn.

Some initial differences between treatments in catches of Carabidae have emerged. For example, in spring barley plots *Bembidion tetracolum* say showed consistently higher LIA than CFP catches whereas the reverse pattern occurred for *Nebria brevicollis* (F.), with higher CFP catches. In oilseed rape *Pterostichus melanarius* (Ill.) was considerably more numerous in traps in the MIN than in the INT treatment. However, as in TALISMAN, the RISC environmental monitoring plots are not replicated so further monitoring will be needed to establish whether these differences in catches represent true effects of the different treatment regimes, natural population fluctuations, or variations in activity.

Other information

RISC is similar in its aim and design to TALISMAN and these projects will complement each other in their economic and environmental monitoring programmes (see Table 4). There are close links between researchers in the economically orientated RISC, TALISMAN and LINK IFS (see below) projects and the environmentally orientated SCARAB project. Together, these projects should provide a considerable amount of information on the economic and environmental consequences of adopting reduced-input farming systems.

Further information on RISC is given in Easson (1993) and in the RISC Report for 1991 and 1992 Seasons (Agricultural Research Institute of Northern Ireland, Hillsborough, Co. Down; unpublished).

There are many other farming practices besides pesticide and nitrogen use which may have a profound ecological impact and these can be manipulated to produce a more intricate farming system. The ecological and economic effects of these are being explored in the LIFE and LINK Integrated Farming Systems Projects which are described below.

LIFE (Less-Intensive Farming and Environmental Research) (1989–1999)

Background

This project, funded by MAFF, was the first to develop and investigate a fully integrated farming system in the UK. The objective is to provide fundamental information on the effects, interactions and ecological implications of an integrated farming systems approach for cereal growing in short rotations, and to develop and evaluate systems of less-intensive production which are both economically and ecologically sound and sustainable in the long-

term. The aims are specifically to:
1. Decrease the cost and improve the environmental safety of arable farming in the UK.
2. To develop integrated control strategies which are compatible with environmental protection (Jordan, 1990).

Design and methods

The experiment was begun in 1989 at Long Ashton near Bristol, South-west England and occupies five large fields totalling 23 ha. Four farming approaches are compared within each of the fields, so the comparisons are replicated five times. The approaches are based on the combinations of two rotations and two farming systems: a conventional and an integrated rotation, each with a standard farm practice system and a less-intensive system which is managed within the Guidelines for Integrated Crop Production (El Titi *et al.*, 1993). Smaller experimental areas within the main treatments are used to examine the yield response to selected components of the system to identify the most influential components. Five-course fully phased rotations of cereals and break crops have been devised for the conventional and integrated rotations.

A range of crop husbandry practices and strategies (Table 3) has been employed to reduce pesticide inputs in the less-intensive systems and these will be flexible over the experimental period. For weed control, herbicides are chosen according to the weed spectrum but must have low environmental hazard, low total active ingredient and low cost. Mechanical weeding combined with reduced doses is used where possible. Disease control is based upon the combination of appropriate rotation, sowing date, resistant cultivars and lower applied nitrogen which reduces the disease incidence and severity facilitating the exploitation of a single-fungicide spray strategy. The pest control strategy relies upon either predictive models (Kendall, Brain & Chinn, 1992) or on site-specific damage thresholds (Glen *et al.*, 1993). All the fields are surrounded by hedgerows with herbaceous vegetation and more recently these have been enhanced by the addition of a 2 m-wide grass and wild flower mixture strip between the crop and field boundary (Greaves & Marshall, 1987).

In each field unit, the incidence of pests, diseases and weeds is monitored, and soil physical, chemical and biological parameters are measured. Collaborative studies are in progress examining soil organic matter content, soil hydrology, run-off, erosion and nitrate leaching. Studies on fertiliser and pesticide movement in the soil are planned. Crop yields, quality parameters and husbandry records provide a detailed economic analysis of each system. Selected species of Carabidae, Staphylinidae and Arachnida are monitored with pitfall traps, and Lumbricidae (earthworm) biomass is also measured.

Principal results

The first three years of this study revealed that the less-intensive system using the conventional rotation was cost effective, providing a 16% higher average profit compared with the standard farm practice system using the conventional rotation even though lower yields were produced (Jordan, Hutcheon & Glen, 1993). This increased profit was achieved through reductions in applied nitrogen (29–31%), herbicides (15–19%), fungicides (>80%) and plant growth regulators (100%). Overall pesticide use was reduced in the integrated system through fewer sprays rather than reduced dose rates. The less-intensive system using the integrated rotation increased profits by only 3% compared with the conventional system. This was achieved through reductions similar to those described above with the addition of a 90% reduction in insecticides.

A marked improvement in catches of some beneficial invertebrates was achieved in the lower input areas. Greater numbers of Carabidae, Staphylinidae, Linyphiidae and Diplo-