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Metapopulation dynamics and grazing systems: the nature conservation importance of management using natural processes in a cultural landscape (the Scottish Highlands and Islands)

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Summary

Nature management is now realising that many species occur in interconnected colonies - metapopulations at the landscape scale. This supports contentions that cultural landscapes, with dynamic mosaics of vegetation over large areas, have ecological importance. Conversely, relict small areas of natural vegetation and highly managed (industrialised) landscapes are of little long-term ecological value. Pastoral landscapes, based on large-scale free-ranging cattle- and sheep-grazing, were once common in Europe — due to various regional management systems which evolved to utilise natural pastures. These are being replaced by intensification or abandonment. Some low-intensity large-scale systems

survive, but their functional importance for nature conservation is not usually recognised in developing agri-environmental schemes. In the Highlands and Islands of Scotland, with a low human population, large tracts of open countryside are cultural landscapes still under the influence of pastoralism. The ecological and conservation value of extensive cattle-rearing are discussed, illustrating the importance of developing mechanisms for maintaining extensive and dynamic grazing systems, rather than the trend for tightly controlled systems characterised by many small compartments and high overall grazing pressure. Methods of reconciling the objectives of free-ranging cattle systems of ecological value and of economic viability are discussed, together with the issue of sustainability.

Key-words: nature conservation; extensive farming

0. Introduction

The introductory note on this Congress indicates that it will "explore how recent conceptual and technological advances in landscape ecology can be translated into management action and policy..." This is the work area addressed over the past 11 years by the European Forum on Nature Conservation and Pastoralism. This paper has its origin in a series of Forum meetings which discussed the functional importance of various European farming systems for biodiversity conservation.

A central theme to what follows is that the ecological processes in these farming systems are complex, difficult to study, poorly understood and often overlooked in the enthusiasm to manage for particular — often conspicuous — species. If there is a message, it is that there is a strong case for nature conservation policies to be objective-driven rather prescription-driven and, in agricultural land, for them to be targeted at the farming system rather than at individual species. This means integrating measures at least at the level of the farm, or landscape-scale.

Another message was stimulated by one of the Congress plenary lectures, which concerned us greatly. There seemed to be an assumption that scientists could always find all the answers, and tell land-managers what to do. At least in our part of the world, there is a lot of knowledge in many land-managers. And we need to find ways of integrating this and learning from them.

In this paper, we wish to:

1. Outline some aspects of European farming & biodiversity conservation, noting particularly the polarisation of farming types, aspects of biodiversity to target, and the challenges of dealing with naturally fluctuating populations;
2. Give an example of Scottish farming systems, and the interactions with cattle grazing required for habitat maintenance, especially of a declining butterfly;
3. Consider the free-ranging extensive cattle grazing systems necessary to maintain these landscapes and whether they can be economically viable; and
4. Look briefly to the future for European cultural landscapes of ecological importance.

2. European farming & biodiversity conservation

Harvest in the Biebrza Marshes, Poland.
Photo: Mike Pienkowski

Landscape scale

In Europe, much of the wildlife interest and the important landscapes, together with the cultural heritage, depend on the countryside as a whole, rather than just protected areas. This is partly because humans have interacted with the natural environment for thousands of years, and because many of the domestic livestock are derivatives of previous wild European species. So, although European farm animals have been exported around the world, causing a mixture of benefit and chaos, in Europe these farming systems have continuity with previous more natural systems — most of which no longer exist. Europe's natural and cultural heritage is thus enriched by the wide

variety of regional farming systems which work in harmony with local environmental conditions. However, many of these farming systems are currently under threat by replacement with systems which are less related to local conditions — but which rely on large inputs of energy and chemicals, and generally reduce wildlife in the areas.

The aims of the European Forum on Nature Conservation and Pastoralism are therefore:

- To increase understanding that certain European farming systems are of high nature conservation and cultural value.
- To ensure the availability, dissemination and exchange of supporting information combining research and practical expertise.
- To bring together ecologists, nature conservation managers, farmers and policy makers to consider problems faced by these systems and potential solutions.
- To develop and promote policy options which ensure the ecological maintenance and development of these farming systems and cultural landscapes.

The Forum is a pan-European non-profit network. It holds conferences every two years, and produces the newsletter *La Cañada*. One of the Forum's means of making its work available to policy-makers is a series of seminars, which are particularly noted for bringing together people working at European policy levels, and those farming and managing land for conservation on the ground. Information on the Forum is available at the web-site.

For many years the emphasis of nature conservation in much of Europe was on the management of sites of special interest. It has become increasingly clear that conservation measures in the "wider countryside", beyond the boundaries of these sites, is necessary to conserve areas large enough to sustain regional biodiversity (*e.g.* Plachter 1996). Hence, there is a need to inform European farming policy — because European cultural landscapes are overwhelmingly the product of human farming activities.

Whilst ancient pastoral-based systems were mostly well integrated with nature, modern agricultural systems have become intensive, and the source of water pollution and abstraction, soil degradation and loss of biodiversity.

This dichotomy — that in some places farming is predominantly destructive whilst in other areas farming apparently sustains regional biodiversity — has lead to a mixed message about the role of farming and an equally mixed bag of environmental policies. These have had limited effect to date. Part of this lack of success is due to the approach to nature conservation. In the fervour to get the environment more recognition in agriculture policies, virtually all initiatives and schemes to date have, as Tubbs (1997) described it, "tended to succumb to the management notion, rooted in the conservation movement's bread-and-butter devotion to site protection, that animals and plants and the habitats they comprise, can be seen in isolation from the farming systems of which they are, or were, integral parts." This has also resulted in some dubious conservation concepts such as "biological networks" consisting of "linear bridges", "corridors" and "stepping stones" linking semi-natural habitats. Plachter (1996) points to the doubtful validity of these ideas as they merely reflect an anthropogenic view of how ecosystems function; an approach not based on empirical observations.

Some components of biodiversity

Ecologists examine cattle dung, Portugal.
Photo: Robin Bignal

The popular view of biodiversity has often been confined to attractive organisms, such as higher animals and flowering plants. Less conspicuous taxa, such as invertebrates, far outnumber these groups. They also make up most of the biomass, and their ecological roles are crucially important, for example through nutrient cycling, pollination, removal of dead and waste organic matter, and as a food source for higher animals.

This is not to say that some conspicuous and attractive species should not be regarded as "flagships" of certain agricultural systems to promote their importance with the public (see Bignal *et al.* 1988). The point is that policies need to address the farming systems, because these are where decisions are taken. Furthermore, at this level, one can address a wider range of biodiversity, rather than the perceived (and often poorly understood) needs of simply individual species.

The European Forum on Nature Conservation and Pastoralism, with partners, identified some years ago the need for information on where farming systems of high nature value still exist. Work undertaken to fulfil this included the initial identification and typology of low-intensity farming systems in nine European countries (Beaufoy *et al.* 1994; Bignal *et al.* 1994; Bignal 1998). A summary map of areas in which such systems still occur and an outline of the typology were produced as a poster/booklet in several languages. One can also see the French, Spanish and English versions on the Forum's web-site (www.efncp.org). The Forum plans to develop this typology to link more closely agricultural systems, their ecological processes and wildlife value, as well as extending its geographical coverage.

An adult chough brings food to its two youngsters. Studies have shown the dependence of this rare member of the crow family - and many other wildlife species - on low-intensity farming. It has been lost from many former haunts where farming is now intensive or abandoned..
Photo: Martin Withers

Population fluctuations and environmental management

Some of the failures of management prescriptions for nature reserves, special sites and agri-environment plans can be explained by the fact that plant and animal populations are dynamic and subject to both spatial and temporal fluctuations, which may not relate directly to changes in environmental quality. This is particularly important on agricultural land because, if fluctuations in population size and distribution are wrongly attributed to management practices, changing that management is unlikely to influence the trend — and could be damaging.

Whilst it is logical to infer that agricultural changes had an influence on population trends of farmland wildlife, most of the evidence is based on correlation rather than proof of causation (Wilson *et al.* 1997). Examples from the UK are the corn bunting *Miliaria calandra*, the corncrake *Crex crex* — in the picture - and the red-billed chough *Pyrrhocorax pyrrhocorax*. All three bird species have populations which have suffered abrupt declines or fluctuations, yet the causes remain elusive despite detailed study. To

add to the confusion for some species (e.g. the chough), adjacent populations can be declining and increasing at the same time. Other species have cyclic changes, for example voles, lemmings, hares and birds of the grouse family. Although often correlated to external factors (weather, parasites, predators), these can also be explained with reference to the intrinsic demographic factors (for example see Moss *et al.* 1996; Bignal *et al.* 1998).

2. An example of some Scottish farming systems, and the interactions of the cattle grazing required for habitat maintenance for wildlife, especially the marsh fritillary butterfly Eurodryas aurinaria

Although we have said that management centred around single species is problematic, we do need ecological results to integrate with farm-management information, if we are to inform farming policies and practices. Therefore, studies have been made on a range of species in the farming systems we outlined, and we take one of them as an example here.

A biologically rich mosaic of habitats resulting from the maintenance and re-establishment of traditional mixed farming in northwestern Islay, U.K.
Photo: Roger Wardle, FWAG

The farmland of Mull and Islay is typified by a mix of upland and coastal grassland, cropped land, moorland, heath, marsh, scrub and woodland. A study of land use, bird habitats and nature conservation on Islay (Bignal *et al.* 1988) concluded that the island held an exceptionally high proportion of semi-natural vegetation despite (perhaps because) of being managed almost everywhere for some form of pastoral agriculture or sporting interest. That study concluded that the vegetation and land types of Islay strongly reflect the influence of extensive stock rearing, utilising pastures of natural vegetation. The diversity of land types results in Islay having one of the richest bird assemblages in the UK (see Bignal & McCracken 1996) including 10 species specially protected under European Union legislation. The eight land types described interlink in different combinations to provide the "functional units" (Tamisier 1979) needed by species to fulfil their needs at different times of the year and at different stages of their lives (e.g. see Bignal *et al.* 1997). In this context the interplay between the "in-bye" land, where crops of hay, silage, cereals and roots are grown, and the extensive pastures grazed by cattle and sheep throughout the year, is of great ecological importance.

Cattle grazing plays a fundamental role also in creating the conditions needed by many invertebrates, especially butterflies. Of particular importance on Islay is the marsh fritillary *Eurodryas aurinia*. This has declined across Europe in the last 150 years, and has its largest populations in the UK (van Swaay 1990; Warren 1993; Barnett & Warren 1995). One stronghold for the species is western Scotland particularly the islands of the Inner Hebrides, including Islay. The caterpillars live in colonies and spin a dense web over the food-plant, the devil’s bit scabious *Succissa pratense*, the colony moving between plants as each is consumed. The vegetation composition and height (between 5 and 14 cms) is crucial (Ravenscroft & Gaywood 1996). Vegetation of suitable height and species composition for the larvae is created through the grazing pressure of cattle and sheep, in vegetation which would otherwise

have unsuitable structure and composition. These suitable patches of vegetation are created in different places over time.

Numbers of the butterflies fluctuate tremendously from year to year. The butterfly relies on networks of habitat patches within which there are periodic extinctions and colonisations (Warren 1994). In areas where large habitat patches exist, permanent metapopulations may survive. In most European regions, however, habitat fragmentation has left few or no large patches where populations are effectively immune from extinction — when these become sink populations, there are no sources from which to receive recruitment.

Colony of marsh flotillary butterfly caterpillars in their web feeding on devil's bit scabious, Islay, Scotland.
Photo: Sue Bignal

Vast modelling resources — and even some field-work — have gone into analysing the minimum viable patches of habitat for various species. This is usually addressed from demographic features of the species concerned. However, if the habitat is itself dynamic and dependent on the behaviour of other animals (cattle, sheep, etc), then requirements of these habitat-managers need consideration also.

Grazing Highland cow and semi-natural vegetation pattern maintained by the grazing system outlined.
Photo: Eric Bignal

For the marsh fritillaries, key habitat-managers creating the essential dynamic patchwork are Highland cattle, grazing in a free-ranging manner. Experience here and elsewhere has shown that their herding behaviour seems to depend on a herd size of about 20 to 25. The semi-natural grazing habitat can sustain an average of between 1 cow per 10 hectares and 1 per 25 ha. A herd of 25 cattle therefore requires about 250 to 625 ha. This then gives an idea of the minimum area for a sub-population in these conditions. The site described and holding one of the best populations of these butterflies covers 370 ha.

These butterflies can fly about 5 to 10 km. This would suggest that several units of land such as that described above, within these sort of distances would be required for maintenance of this species. Islay, which supports one of the best surviving populations, does indeed hold several such areas within its total of 20,000 ha.

A key point about the extensive cattle pastures in Islay and Mull is that they provide the ecological context within which natural processes can operate; they provide suitable conditions for a range of species (often with particularly volatile populations) which are susceptible to habitat fragmentation. This can apply to plants, birds and invertebrates. It is more important to retain the integrity and biological potential of the functioning landscape than to compartmentalise management. Referring to the marsh fritillary butterfly, Warren (1998) comments "it is undoubtedly one species that requires habitat conservation at the landscape level, on a scale that traditional conservation measures have yet to tackle".

3. Free-ranging extensive cattle grazing systems necessary to maintain these landscapes, and their economic viability

Recently Dennis (1999) highlighted the ecological need for wide-scale cattle grazing to enhance woodland biodiversity in the Scottish Highlands. Many of his points have much wider applicability. In woodlands the cattle can create structural diversity; and in grasslands, heaths and marsh they can encourage conditions which favour floristic diversity and the micro-habitats needed by invertebrates, mammals and birds. Essentially they introduce small-scale perturbations to the vegetation, resulting in an increase in biodiversity (see Kampf 1998). Their herd behaviour can introduce seasonal and cyclic pressures which are virtually impossible to produce in any other way — not only through their grazing but through their trampling, dunging, resting and ruminating in favoured places, and selecting foraging areas in relation to the seasonal availability of herbage.

The problem is that few modern cattle systems utilise primitive breeds or raise livestock at the densities noted earlier that mimic the impact of the aurochs (the ancestral wild cattle).

Traditionally in Scotland and elsewhere, cattle would be moved to summer pastures (transhumance) and herded, during which time the best of the lower land would be cultivated. This pattern of land-use created a mosaic of pastures, meadows and crops both in the hills and on the low ground. Few animals other than the breeding stock would be kept over the winter.

Cattle rearing in the Scottish Highlands and Islands during the past decades has changed markedly. Farms have become more specialised with many former mixed livestock farms now keeping only sheep. Even the more traditionally managed cattle farms in remote areas changed their management practices, often using as pasture land that was formerly cultivated and forsaking the hill pastures. Many former pastures are now exotic tree plantations; afforestation is generally a component of the intensification and polarisation of land-use.

Highland cattle on northwestern Islay, with supplementary winter feed grown on the same farm, giving the valuable mosaic of habitats shown in other pictures. Photo: Eric Bignal

One question has been whether it is possible to connect the apparently opposing objectives of a free-ranging stock system of ecological value with economic viability; and if it can be sustained. Bignal, McCracken & Mackay (1999) give examples of these systems in the Scottish islands. What is being done there is linking the product to the environment in which it is produced, so that the market price takes that into account. Another good example in Hindelang, in southern Germany, is described by Roman Haug (1998) in the Aosta proceedings of the Forum. Here, there is an effective collaboration between farmers, shops and tourism industry to support the environment on which they all depend.

4. The future for European cultural landscapes of ecological importance

To what extent can such approaches be spread widely? The current trend is still for traditional low-intensity systems and their management practices to be replaced by intensified systems (e.g. see Goss et al. 1998). Low-output small farmers are often regarded as economically inefficient because their production is small — although, if environmental costs were taken into account, they could be

A cereal crop is being harvested below the olive trees in Iberia. Multiple uses of land often resulted from traditional and sustainable land-uses. However, many EU policies are designed for single types of crop grown intensively.
Photo: Eric Bignal

described as efficient low-input/low-output systems. Yet at the same time policy makers and government officials are making it clear that there will have to be greater environmental benefits if farmers are to continue to receive public support. This raises a fundamental contradiction because generally biodiversity is highest on "low-intensity" farms with low inputs and low outputs, and where farming practices are to a greater degree shaped by the constraints of the natural environment (Bignal & McCracken 1996).

Sustainability tends to refer to a balanced relationship between environmental, social and economic goals (Bauer & Mickan 1997). In most modern agricultural situations the linkages between these three aspects have become increasingly tenuous with each acting in a more isolated way under influences which are external to the farm.

The challenge is therefore to address the decline of low-intensity, ecologically diverse, sustainable farm systems, and the landscapes, biodiversity and human communities to which they give rise.

Circumstances in Europe are changing, giving the opportunity for further policy reform. There is not the time to explore this here, but we have done so elsewhere (Goss *et al.* 1998; Tubbs 1998; Pienkowski & Bignal 1999). Essentially, future policies will need to shift financial support structures away from intensive agricultural production towards broader socio-economic objectives in which the maintenance of low-input, biologically diverse systems and their rural communities is paramount.

We need to input knowledge into policy development. However, we need to be clear that many of the ecological aspects of farmland are not well understood. Application of the precautionary principle to conservation management and greater appreciation of the biological importance of existing practices is needed. In many cases the most appropriate management is not always obvious and there is rarely any scientific research to rely on. Greater appreciation of the need for long established farming practices to remain as the central focus is required. For example, when extensive pastoral management of farmland of high biodiversity is replaced with highly prescriptive, compartmentalised management aimed at individual species, fundamental changes to the landscape and the biological character can occur.

Moreover, such management is out of context with long-established farm management and relies heavily on external inputs of labour and finance. It generally involves no ecological accountability with respect to overall farmland biodiversity nor inconspicuous species. Importantly it gives the wrong signals to farmers, namely that traditional management has to be replaced to make it of environmental value, and promotes a system of management which is not sustainable (see Bauer & Mickan 1997; Bignal *et al.* 1999.).

Sheep and their lambs are gathered by a farmer and his sheep-dogs during management operations in a low-intensity farm on Islay in the Scottish Islands.
Photo: Mike Pienkowski

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