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Farm–Nature Plan: landscape ecology based farm planning

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Abstract

A procedure is presented for restyling the lay-out and management of farms in order to increase the biodiversity in the agricultural landscape as well as the sustainability of farming. The protocol for the development of an on-farm Nature Management Plan explicitly uses landscape ecology characteristics, local biotic and abiotic data and potential, as well as the farming system data and farmer's personal interests. It may also enhance the farmer's interest and understanding of agro-ecological pattern and process and induce a more conscious approach to elements of nature on the farm, which may be the starting point in ecologising agricultural practice. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

The integration of nature and farming is an important issue in scientific and political circles in industrialised European countries because, in the first place, the populations of many plant and animal species associated with agricultural land are declining in many Western European countries. Changes in agricultural land-use are often suggested as the main cause of this decline (e.g. Wilson et al., 1997; Fuller et al., 1995; Andreasen et al., 1996). These changes have concomitantly had an effect at the landscape level, resulting in a loss of landscape differentiation in Europe (Bal-dock et al., 1993).

At the IUCN conference 1992 on biodiversity in Rio de Janeiro, most European governments committed themselves to implementing biodiversity conservation measures. In the Netherlands, these commitments are

now being translated into deeds. Agriculture, the land-use accounting for about 50% of the country's area, is not excluded from these efforts to conserve biodiversity, since the occurrence of many species and communities is related to farmland and farming practices.

Apart from its intrinsic value, biodiversity has a function in a number of ecological processes highly relevant for food production. These 'life support functions' of biodiversity include the soil nutrient cycles (Brussaard et al., 1997) and regulation of pests by means of biological control (Altieri, 1994). Agrotechnology has broadly increased the independence of these functions at the cost of high inputs of fossil fuel, artificial fertilisers and pesticides. The concept of 'sustainable' agriculture aims to re-establish an equilibrium: life support functions and technology should be farm attributes of equal importance. Here, the integration of farming and nature comes into play.

From both perspectives — the intrinsic and functional value of biodiversity in agriculture — there is a

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Table 1
Important structures and processes on the landscape and the farm levels as related to the ecosystem components

Component:	Landscape level (reference)	Farm level (field of operation):
Climate	exposure to sun and wind, mesoclimate	shade, shelter, <i>erosion, deposition</i>
Soil	soil type, inclination, soil/height transitions (<i>soil formation</i>)	<i>managing</i> nutrient - and organic matter status, <i>tillage, disturbance</i>
Water	Catchment area (river), <i>watertransport:</i> <i>inundations, seepage, infiltration, leaching or</i> <i>accumulation minerals, land-use planning</i>	ditches, drains, ponds, wells, <i>water management</i>
Physical structures (man-made)	roads and banks, dikes, urban zones, <i>construction</i>	buildings, tracks, fences dumps/piles, <i>transports</i> <i>of matter, construction</i>
Vegetation	present communities (including forest, nature reserve), <i>succession, population dynamics, dispersal</i>	pastures, arable crops, weeds, vegetation of linear habitats, <i>dispersal, management and control</i>
Fauna	vertebrates and migratory invertebrates, migration, population dynamics	present species, domestic animals, <i>dispersal,</i> <i>population dynamics</i>

strong need to develop farming systems that include biodiversity (Almekinders et al., 1995; Vandermeer et al., 1998). These ideas are particularly manifest in the current practice of organic farming (EEC, 1994). The standards for organic farming guarantee safer conditions for biodiversity development by banning the application of pesticides and artificial fertiliser and by encouraging long crop rotation and moderate stocking rates. Nevertheless, organic farms also lack a clear perspective when it comes to integrating nature on the farm.

In this article, we argue that the integration of farming and nature in the context of a sustainable agriculture (including the management and conservation of biodiversity), should comprise two levels: the landscape level (100–1000 ha) and the farm level (10–100 ha) (Table 1). As regards the landscape level, there should be coherence between the structure and distribution of the non-productive (green) habitats on the farm and in the surrounding landscape. The reason is that conditions supporting biodiversity on the farm are strongly related to processes and structures at the landscape level. The first question, therefore, is: what are the implications of this landscape-level focus for farm nature? At the farm level, these green habitats should be clearly and purposefully integrated with farm management. Only if habitat structures and distribution are compatible with (or beneficial to) the agricultural production, will they be able to survive and, as a result, biotic complexity be able to increase.

The second question to be addressed is: what does this farm-level focus imply for nature on the farm?

The third question is an extension of the preceding ones: how can these implications be worked out for real farms, e.g. in a 'Farm–Nature Plan'? How can farms actually be 'restyled' in order to achieve a better coherence with landscape patterns and processes and a better adjustment of farming to nature? The outlines of a procedure for such an on-farm implementation will be presented below. This protocol for a Farm–Nature Plan is currently being tested in Dutch agricultural practice, mainly on organic farms, without subsidies and on a voluntary basis.

2. Farm in the landscape

The question of why this 'coherence' between the green habitat's structure and distribution on the farm and at the landscape level is so important for the biodiversity can only be approached at landscape ecology level and has to include agro-ecosystem functioning.

At the beginning of this century, traditional farming was broadly in accordance with landscape ecology characteristics and processes. The technical and economic constraints to farming were directly related to limiting natural resources and conditions. Crops, livestock, tillage and manuring had a spatial distribution reflecting the prevailing abiotic conditions. This land-use pattern resulted in a gradient in use intensity and productivity from the farm settlements outwards. In addition to this spatially differentiated land-use, the use of each area was the same over the years, i.e.

constancy of processes. This traditional land-use resulted in a high biodiversity (Westhoff et al., 1970; van Leeuwen, 1966). However, increasingly, and especially since 1950, improved technology and welfare have allowed agricultural land-use to become independent of natural resources and the increasing inputs of artificial fertiliser and mechanisation have levelled out the habitat variation. Nevertheless, modern agricultural landscapes still harbour abiotic and biotic diversity. This variation often reflects vital ecological processes, particularly related to the ecohydrology (Everts and de Vries, 1991).

The data from plant and animal species inventories are extremely valuable. Because vegetation succession and species immigration mostly take decades to be accomplished (van Dorp, 1996; Hermy, 1994), it is difficult to conclude the potential suitability of a location for certain species. Therefore, structures and processes at the surrounding landscape level have to be used as references and resources for biodiversity at the farm level.

How can pattern and process at the landscape level (Table 1) be assessed in order to achieve such coherence between the habitat infrastructure of farm and landscape? If we look at the landscape level there are three ecological keynotes to be addressed:

- *similarity*: the promotion on the farm of plant and animal populations already occurring in the region, most effectively enhances the farm biodiversity. Semi-natural (green) habitat types found in the surrounding landscape could be present or constructed or reinstated on the farm; a farm in an open landscape could have a solitary tree or some shrubs, but is better not planted with woodlots or hedges.
- *connectivity*: ecologically related habitats (wet, wooded, herbaceous) should be connected or be located within a certain distance in order to guarantee a minimum territory size within the reach of dependent animal species (Opdam et al., 1993); the on-farm green habitats should link up with the habitat network present in the surrounding landscape;
- *variation potential*: the variation in soil and hydrological conditions at the landscape level as well as the processes at work on a landscape scale

acting as agents for variation (e.g. causing ground-water seepage zones, flooding) should be exploited when planning habitat arrangement and habitat management at the farm level.

If these three keynotes are addressed on a number of contiguous farms, their common landscape context will lead to compatible green infrastructures that will positively influence each other and may also restore characteristics of the landscape. This synergy or positive feedback may have the character of a restoration, but includes economically feasible farming.

When the three landscape level keynotes are applied to the ecosystem components at the farm level, a number of recommendations can be identified (Table 2):

- climate: general exposure to sun and wind, rainfall are the same for farm and landscape;
- soil: different soil types and transitions may extend into the farm area, which could be expressed by botanical composition; this can be enhanced by applying special management on selected (promising) habitats (e.g. establishing grassy strips, removing biomass after mowing);
- water: influx of nutrient-rich or polluted water from the surrounding area may strongly influence on-farm habitat conditions; this should be restricted if possible; differences in groundwater quality extending into the farm area could be expressed in the local species composition (Everts and de Vries, 1991); deepening of a ditch or construction of a pond should be linked with the surface-water network; distances up to ca. 300 m enable amphibians to disperse;
- vegetation: woody elements (hedgerows, woodlots, individual shrubs and trees), can be planted to expand the woody network or reinforce existing patterns or isolated woody elements in the landscape; management of woody, dry or wet herbaceous vegetation should refer to examples in the surrounding area that demonstrate subsequent developmental stages and species-rich communities;
- fauna: measures for the promotion of certain species could focus on resident (vulnerable) species; to avoid disturbing large species, particularly meadow birds, these efforts could best be at least 200 m away from settlements and main roads.

Table 2
Developing a Farm–Nature plan by translating ecological information (about structures and processes) to recommendations

Component:	Landscape level recommendations:	Farm level recommendations:
Climate	–	utilise differences in microclimate
Soil	utilise relief, soil-type, transitions	nutrient application in consistent patterns in space and time; no input outside fields
Water	correspond to flow patterns, seepage water quality (i.e. the general ecohydrology)	manage water quality, quantity and links: retention, rising water table, creating new ponds and marshes
Physical structures	consider vicinity of roads and buildings (disquiet)	enable nesting and hiding of animals
Vegetation	reference communities under consistent (nature) management; improve spatial linkages or maintain separation	creating and/or linking of similar habitats; consistent management method in a consistent distribution pattern; moving mainly with biomass removal facilities and protection measures
Animals	reference communities, including species with a large homerange	

3. On-farm nature

The previous section considered the coherence in pattern and process between the farm and landscape level and recommendations were derived for the farm. Now, we will emphasise pattern and process at the farm level proper, including the related activities and management. The challenge here is to establish an explicit link between the farming measures and the desired developments in farm nature.

A number of structures and processes at the farm level can be important. Features at the farm level are summarised in Table 1. How can these structures and processes be assessed and addressed in a farm–nature plan? Here we will use four farm-ecology keynotes comparable to the three keynotes at the landscape level:

- *surface area*: a certain part of the farm area should comprise green (i.e. semi-natural or extensively managed) habitats and serve as a refuge and a source of variation. In a number of cases an area of 5% of the farm has been recommended (Vereijken et al., 1994);
- *connectivity*: similar habitats on the farm (wet, woody, herbaceous) should be connected or located within a certain distance in order to ensure that dependent animal species have at least the minimum territory size and can disperse across the farm (Opdam et al., 1993);
- *variation*: a variety of habitats should occur on the farm; variation can be added within the predominant habitat types by applying different

management forms and thus accommodating different plant species and animals that, e.g. require variation in prey and resources; this holds for generalist predators of pests, who need ‘alternative prey’ when pest populations are low (Altieri, 1994). Variation also relates directly to biodiversity;

- *habitat quality*: extensively managed habitats should be protected from manuring and soil disturbance in order to allow communities of older successional stages to develop; to facilitate vegetation succession and small-scale differentiation in ecological gradients there should be as much continuity in the year-to-year management as possible, including the use of the fields (Westhoff et al., 1970); some vertebrate species require additional measures to compensate for or protect against threats in the production area, e.g. protection of meadow bird nests (Beintema, 1991).

When the four farm-ecology keynotes are applied to the ecosystem components at the farm level, a number of recommendations can be identified (Table 2):

- microclimate and climate: establishment of sheltered and sunny places; in open landscapes shelter can be provided by shrubs, reeds or even tall perennial herbs; ditch banks or ponds with a sunny aspect should have priority when extra efforts are made in vegetation management.
- soil and soil fertility: any manuring or emission of nutrients outside the production area should be avoided. The margins of pastures and, if possible, the edges of arable crops could, therefore, receive

less manure; difference in the fertility of fields should be emphasised; on marginal fields on arable farms a less intensive crop rotation can be considered.

- farm buildings: access and nesting facilities for birds (swallow, barn owl) and mammals (hedgehog, stoat) could be offered;
- water: the potential for conserving relatively nutrient-poor groundwater and rainwater on the farm should be exploited; sometimes the direction of flow can be changed and the effects of good water quality extended; the water level in some ditches could be raised by damming. If the landscape type permits, wet elements or deeper water can be created.
- vegetation: if the landscape permits new linear woody elements of at least 3 m width to be established; the rule of thumb regarding the movement of birds, bats and butterflies is 100 m between trees and shrubs; the pattern of wet, woody and herbaceous elements around fields should be as interconnected as possible; a gap should never exceed 200 m (radius of action for stoat and songbirds). Plots should preferably be no larger than 8 ha. There should be a realistic and not too complex annual planning of the vegetation management of verges and ditch banks, that provides for differences in growing stage between or even within linear elements; there should be a consistent differentiation in land-use in pastures, if stocking rate permits.

4. Protocol for a Farm–Nature Plan

How can organic or other farms be modified in order to achieve coherence at the landscape level and integration of nature at the farm level? The above recommendations were derived from both levels. The Farm–Nature Plan protocol (Smeding, 1995) was developed for this purpose. It is a stepwise procedure that leads to a map of the farm including site-specific recommendations.

The Farm–Nature Plan protocol has five steps:

- *the attunement*: a talk with the farmer about his perception of nature on the farm, his wishes, technological possibilities and constraints;
- *the survey*: a field visit of two days to identify and describe all relevant features, resulting in (1) a 1 : 5000 map of the farm, (2) a 1 : 25 000 map of the landscape, (3) a list of different habitat types and their areas and (4) a short report on observations of habitat structure and composition; only conspicuous indicator species need to be identified; information is also collected about land-use planning policy and nature management subsidies relevant for the farm;
- *the appraisal*: an evaluation of the farm with regard to: (1) the area of non-farmed habitats, (2) the connectedness of similar (wet, woody or tall herbaceous) habitats on and around the farm area, (3) the variation and (4) quality of farmed and non-farmed habitats;
- *the choice of objectives*: a decision on site-specific and realistic objectives for the farm; the decision is based on ecological criteria (appraisal), the farmer's preferences and management possibilities (attunement) and local land-use policy and subsidies (survey);
- *the design*: starting from the objectives and the farm map, several points of attention are checked; at this stage, the list of recommendations (Table 2) is consulted to establish landscape coherence and compatibility with farming practices; the result is a map of the farm area including the existing and planned distribution of green infrastructure, with practical recommendations; in this last step in particular, scientific/ecological judgement is to be combined with creativity when finding alternative acceptable solutions.

By way of an example, let us consider the Farm–Nature Plan made for the A.P. Minderhoudhoeve experimental farm (Lantinga and Oomen, 1998), a 89-ha mixed organic farm in a polder dominated by arable production. The plan (Fig. 1) involved increasing the total area of non-farmed biotopes from 2.8 to 5.8%. Four sown grassy banks interlink the herbaceous network and divide extended areas of arable land into plots of 9 ha or less. The management in the ditches is varied, with the aim of achieving a tall herb structure (common reed) and a poorly productive vegetation with increased flowering performance. The vegetation quality of the ditch slopes is guaranteed by means of a grassy field margin and an overall

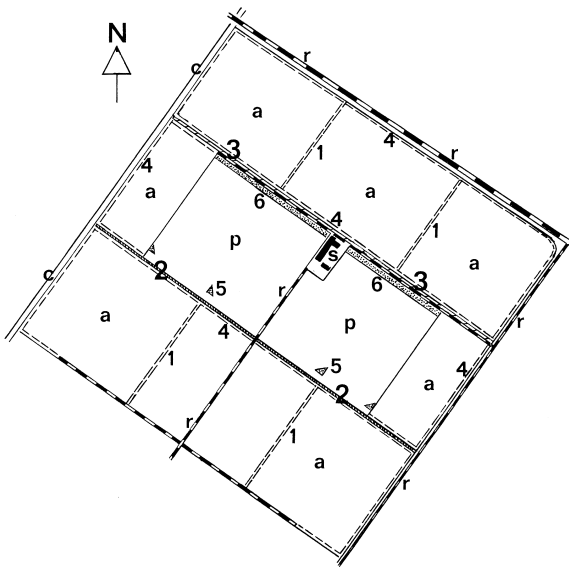


Fig. 1. Farm–Nature Management Plan for the A.P. Minderhoud-hoeve-WU experimental organic farm (89 ha). a, Arable field; p, permanent pasture; s, farm buildings; c, canal; r, road with verge(s). Measures (width): 1, grassbanks (3 m); 2, ditch/common reed (5 m); 3, ditch rich in flowering herbs (5 m); 4, grassy field margins (3 m); 5, shrub corners (25 m²); and 6, hedgerow (3 m).

mowing regime with biomass removal. The ditch with tall herbs plus shrubby corners and a newly planted hedgerow are intended to provide a shelter network for insectivorous songbirds and small mammals like stoat and weasel. Additional measures are taken to protect and facilitate the nesting of swallow and black-tailed godwit.

The protocol was developed in collaboration with the Dutch National Extension Service and tested in 1995 on three organic farms (Smeding, 1995). In 1996–1997 extensionists made 27 Farm–Nature Plans for Dutch – organic farms, ranging from dairy and arable to fruit production, and distributed over the various regions in the Netherlands (van Almenkerk and van Koesveld, 1997). In 1998, 70% of the farmers involved responded to a questionnaire: 40% of them had implemented the recommendations and 35% intended to do so in the future. About 70% of the farmers involved use the Farm–Nature Plan in discussions with the local government, water boards and nature conservation authorities.

5. Discussion

The development of farming systems that include biodiversity management is a complex topic. The approach presented in this article emphasises coherence between farm and landscape features and integration of non-production habitat and farm management. As explained above, this approach is subsequently elaborated into an advisory instrument (protocol for Farm–Nature Plan) which assumes that the farmer will collaborate and participate actively.

The approach does not pretend to be final and comprehensive; the Farm–Nature Plan protocol follows only one particular line of reasoning, applying field experience and scientific evidence mixed with professional judgement. However, the complex system of a farm can also be approached from another perspective; for example, historical development, spatial relations or different levels of integration (crop, community, region). Certainly, more scientific research could always be done before giving practical recommendations at the farm level. However, despite such criticism, each alternative line of the planning of farm nature, including the implementation, tends to pose comparable problems.

One advantage of the approach presented is the well-structured framework that enables open discussion and improvements. The results of practice-oriented scientific research can be fitted into this framework, improving the criteria and guidelines. Important research topics include: the selection of indicator parameters at different levels, food webs on farms, dispersal requirements for plants and animals, necessity of plant species introduction, etc.

A further advantage is that the protocol is transparent and can be applied by non-academics, because the emphasis is on observation of structures and general characteristics of species and vegetation. Last, but not least, the farmer's involvement in designing a Farm–Nature Plan is essential. The results are strongly dependent on the farmer's good intentions, understanding and accuracy in the timing and positioning of actions. The protocol and Farm–Nature Plan seem to be effective tools in restoring landscape and farming sustainability. As well as having a high-tech context, precision farming (Rabbinge, 1997) may also refer to a keen understanding and use of ecological patterns and processes and a tolerant attitude towards nature

elements on the farm: managing biodiversity as the starting point for ecologising agriculture.

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