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Ecological consequences of grazing extensification and land abandonment: Role of interactions between environment, society and techniques

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SUMMARY - This introduction addresses the main reasons to reconsider research on the ecological consequences of land abandonment. 1) There is a social demand for nature and landscape that is being integrated in planning and management policies. 2) Land managers are creating new techniques for controlling succession on abandoned land. 3) The recent emergence of landscape ecology, agro-ecology and hierarchy theory within the field of ecology allows new approaches of the problem. Then we pose several questions on the expected ecological benefits or losses of abandonment, to be addressed during the meeting. A crucial point is our ability to predict changes in land use patterns. This can only be done by integrating the ecological, technical, economical and social factors that drive these changes.

Key words: Abandonment, landscape ecology, agro-ecology, agricultural economic.

RESUME - "Conséquences écologiques de l'extensification du pâturage et de l'abandon des terres : rôle des interactions entre l'environnement, la société et la technologie". Nous présentons en introduction les raisons principales qui nous mènent à reconsidérer la recherche sur les conséquences écologiques de l'abandon des terres. 1) Il existe actuellement un grand intérêt de la société envers la nature et les paysages naturels, intérêt que l'on observe également dans le domaine de l'aménagement et de la gestion. 2) Les dirigeants chargés de l'aménagement mettent en oeuvre de nouvelles techniques afin de contrôler la succession sur les terres abandonnées. 3) L'apparition, récemment, des notions d'écologie du paysage, d'agro-écologie et de la théorie de la hiérarchie dans le domaine de l'écologie, nous permettent une approche de cette problématique sous un angle nouveau. Nous soulevons également, lors de ce séminaire, plusieurs questions relatives aux bienfaits ou préjudices écologiques escomptés en ce qui concerne l'abandon des terres. La possibilité de prévoir les modifications de l'utilisation des terres est d'une importance capitale. Ceci ne peut être mené à terme que par l'intégration des facteurs écologiques, techniques, économiques et sociaux qui président à ces changements.

Mots-clés: Abandon, écologie du paysage, agro-écologie, économie agricole.

Introduction: the problem

Land abandonment in itself is not a new phenomenon. It has been constant in western Europe since 1950 (Meeus *et al.*, 1988) and has been widespread in eastern North America from 1920. Expansion or shrinking of agricultural land area also is common at historical scales of time. In Europe such events as wars and the Black Death caused the abandonment of whole regions. Ecological consequences of such events have been addressed many times (e.g. EGPN, 1987) and the literature on biotic colonization of abandoned land and ecological succession, the obvious consequences, is abundant (e.g. Gray *et al.*, 1987).

The need for this seminar, and further research, is due to several new social, technical and scientific points.

Social Factors

In Europe land is being abandoned because of excess production of specific agricultural products and application of advanced technology and fossil fuel subsidies to the agricultural enterprise. In part it is the contraction of an economic enterprise, which expanded in past time

into what are now marginal areas. First, the least economically desirable lands are abandoned and then, as the agricultural enterprise is transformed, further abandonment proceeds. What begins as a partly spontaneous process becomes an administrated process since agricultural productivity is regulated and controlled by government subsidy, by support of infrastructure and by economic control of markets and prices. The decision makers and planners attempt to retain those elements of rural society that maintain a rural culture, reduce the negative social impacts on farmers, their family and rural associates, and still fit production of products to demand.

As the process of adjustment proceeds, the amount and distribution of land is a variable that can be adjusted to achieve a specific goal.

Beyond these social needs, the economic problem to the land owner is how to market and sell the rural environment now that it is no longer needed for production. The sequence of steps may include first consideration of alternative modes of agricultural production, alternative ways to use land to provide income and, then, government programs designed to retain certain desirable practices or to support certain goals of broad social value, such as conservation of the biota.

While the impacts of land abandonment are being studied and debated, more research is needed into the entire phenomenon from a social system perspective. The economic and social impacts need to be considered with the environmental effects since we are dealing with a regional process that influences all elements of the rural system.

Technical Point

We are seeking techniques to manage abandoned land. These techniques must be derived from agricultural practices, and even be adapted to their new goals. They might include grazing (Loiseau and Merle, 1981; Thalen *et al.,* 1987), mowing with or without removal of biomass (Gryseels, 1989), use of fire, reforestation, and so on. Of course the emergence of techniques is only possible because land abandonment is occurring in a society which can afford to pay landscape managers. This is totally different from abandonment taking place after the collapse of a society.

Scientific Points

In the field of the ecological sciences, there is current development of three closely related approaches: landscape ecology, agro-ecology and hierarchy theory, which are applicable to understanding land abandonment.

Landscape ecology studies the effects of landscape heterogeneity on ecological processes. The focus is on interactions among landscape elements (Forman and Godron, 1986), and the development of landscape structures through time. It focuses on large scale spatial structure and enhances the understanding of ecosystem studies (Golley, 1987). Landscape ecology provides a foundation for land planning and management.

Agro-ecology "seeks to describe the state of the rural system in a broad way so that we can understand what is presently happening and then to show the costs and benefits of various alternatives" (Golley and Golley, 1988). The interactions between ecological processes and agricultural practices are the driving forces that shape landscapes and the state of the land at any scale (Lowrance *et al.,* 1984; Paoletti *et al.,* 1990).

Hierarchy theory does not address a specific object of research, such as landscape or agricultural systems. It stresses the importance of considering several levels of organization as well as the resolution scale at which an investigation is carried out. The choices of the hierarchical description is of overriding importance since it will affect the outcome of the research, as well as the range of validity of the models. The seminar book of Allen and Starr (1982) provides a discussion of the basic concepts and principles. Rural landscapes are hierarchically organized. Conceptual and theoretical developments regarding sampling and data analysis (the "scaling up and down" procedures) must still be developed; for us it is important to present the extension of our study in space and time as well as the scaling strategies in research, during data collection and data analysis.

Within the framework of these approaches, we stress that land abandonment and the subsequent phenomena derived from land abandonment are occurring within a landscape, and are reflected as a change in landscape structure, and within an agricultural system having specific technical and socio-economical characteristics. Any field or enterprise, is embedded in ecological and social hierarchies that will control its fate.

Objectives of the Meeting

The objective of this meeting is to evaluate the state of knowledge, point to recent advances, and give directions for further research for a more integrated perspective on the conditions and ecological consequences of land abandonment. This information is required for policy makers to establish guidelines and manage change in the rural landscape.

Land abandonment: a definition

Before developing some of the ecological questions and the need for modelling land use changes, it is useful to define "abandoned land". Here the term will not be

used in the restrictive sense of "land no longer used either by agriculture or any other rural economic activity". Rather, land abandonment means change in land use from the traditional or recent pattern to another, less intensive pattern. As a matter of fact, a conversion from ploughed land to permanent grassland, with no or few inputs, can be seen as a form of "abandonment"; ecological processes play an important role in controlling plant species composition. Trends toward extensive grazing of grassland also exhibit features of abandoned land, and land may be reforested or allowed to revegetate naturally and form conservation or recreation land uses. Our use of "abandoned land" includes all such usages.

1. Ecological approaches

1.1. What are the expected positive effects?

Any policy and any management operation ought to have a goal. What are the ecological reasons that make land abandonment desirable? Can ecological improvement only be obtained by natural succession? What does the society want; what is feasible?

One of the goals may be to increase species diversity, but are all species equally good? Perhaps a less diverse flora or fauna with rare species is a better goal? What is a rare species, is it rare because its habitat has been reduced in the past or for another reason? Can rare or endangered species benefit from abandoned land? Are there suitable habitats, and available propagules? These questions are relevant to a conservationist who advocates the creation of nature reserves on abandoned land.

Many people worry about the fate of weeds that have been introduced with cereals as well as other species that migrate over centuries in open space. They certainly increase biodiversity, but how do they affect criteria such as "naturalness" or "typicalness" (Usher, 1986).

Society may also wish to enhance other ecological processes such as soil conservation or restoration, water purification, reduction of erosion, biological control of pests. Beauty of the countryside may also be an objective.

1.2. Possible negative effects

Negative ecological effects are also expected from land abandonment. Fire, dereliction, invasion of aggressive species in eutrophic zones (Gryseels, 1989), expansion of weeds and diseases can also be caused by land abandonment or set aside schemes. Possible conflicts between countryside protection and nature conservation may occur, such as afforestation of open areas.

1.3. Driving factors

It is not the purpose of this introduction to present a comprehensive review of the ecology of abandoned land, my intent is only to list factors known to affect ecological dynamics in order to try to assess their importance.

1.3.1. *Field conditions*

* *Physical and chemical soil conditions and the role of agricultural practices:* soils that have been farmed by centuries have been highly transformed. Usually their organic matter content is lower than in natural soils (Cox and Atkins, 1979), erosion has changed soil texture and, recently the use of pesticides, pollution by heavy metals (in vineyards, or from pig sludge or atmospheric pollution) may have transformed habitat conditions (Brouwer, 1989) and even be a cause of abandonment.

The nutrient content of soils, which strongly influences species composition, partly results from natural conditions and partly from former farmers' practices (manuring, herd management). Practices vary from place to place within a geographic region. For example, in their study of the Monts Dômes, Bazin *et al.,* (1983) report that during the night sheep were bedded on arable land to manure it. After abandonment, the nutrient content of the soil decreases and can be the main factor causing changes in species composition (Balent, 1987).

The role of former agricultural practices has certainly been overlooked by ecologists, while agronomists have shown little interest in the mechanisms of ecological land dynamics after agriculture. For example, in the Vosges mountains of eastern France, the former land use influences the types of species invading abandoned land; former arable land is more readily colonized by woody species than are grasslands (Auricoste *et al.,* 1983).

Terraces were very frequent in the Mediterranean zone. Because they are inconvenient for modern agriculture, they were abandoned, which favours soil erosion and dereliction. In this case, the physical conditions of the site change after abandonment.

* *seed bank:* weeds are commonly the dominant species in abandoned arable land. Weed seeds accumulate on these fields; they even have been selected by herbicides. Unless there is natural vegetation nearby, nonweed species seeds may be slow to invade the site. For example, lack of species in the seed bank is a problem for the restoration of chalk grassland, (Graham and Hutchings, 1988).

* *agricultural practices at the period of abandonment:* a field can be abandoned in various ways, there may be no intervention after a crop, or grazing may take place, grassland grazing may be more and more exten-

sive, with lower and lower stocking rates. These different forms of abandonment will change the environmental conditions for colonization by plants and animals and subsequent successional processes. If maintenance of species rich meadows is desirable, we must know the minimum grazing pressure to maintain the sward. Because vegetation responds slowly to instant changes in management practices, invasion by semi-woody species may take place years after extensification starts. Can this process be detected early in changes in sward species composition?

Sensitivity to initial conditions deserves more attention, it may even be a source of management guidelines, as, for example on the use of pesticides to modify herbivora and thus dominant species (Brown *et al.*, 1988)

* *field margins:* after the soil seed bank, field margins are the main source of propagules. Field studies on the role of field margins are numerous in Britain for arable land (Way and Greig-Smith, 1987), but not elsewhere in Europe. Use of herbicides prior to abandonment changes the margin species composition, diminishing species diversity and increasing the chances for aggressive species to colonize the field. As widening field margins is a possible option for set-aside, it is certainly worthwhile to have a close look at them.

When hedgerows are present they can provide species of late successional stages, but there are important differences in the colonization ability among hedgerow species (Burel and Baudry, in press).

* *size and shape:* the effect of size and shape of the patch species composition is important for the development of landscape ecology (Burgess and Sharpe, 1981). Large areas can provide shelter to coarse grain species and to "interior species". But we can hypothesize that the center of large abandoned areas will be more difficult to colonize for ground herbs or invertebrates, the benefit of being large will only appear at later stages. Shape modifies the edge/interior ratio for a given area; round shape minimizes it.

1.3.2. *Landscape conditions*

Fields are patches, spatial units, closely connected to surrounding fields. Landscape spatial structure drives fluxes of species, water, nutrients etc... Structures change through time because of human activity (changes in land use patterns), and natural processes (successions). As a large literature is available on these processes, I will only briefly consider aspects that might be useful to consider during this seminar.

* *landscape structure:* Grain size, heterogeneity, connectedness are the most commonly described features.

Grain size describes the average size of landscape elements (Forman and Godron, 1985).

Heterogeneity refers to the diversity of landscape elements, their fragmentation, frequency, distribution in space. Methods to measure heterogeneity can be found in Baudry and Burel (1982), and O'Neill *et al.*, (1988). Land abandonment increases heterogeneity if patchy, and/or because physical differences that were hidden by agricultural practices show again. Abandonment can also be connected with intensification on the most productive land, which increases contrasts.

Connectedness refers to the structural links between elements (Baudry and Merriam, 1988). Usually connections are made by corridors that may enhance species movement but also act as barriers.

* *sources of species and fluxes.* To be present in one place species must either be present in the seed bank or disperse from existing patches. Successional patches, moorland, and woodlots are the main sources of species for abandoned land. Proximity to seed or species sources will affect pathways of succession. With the development of landscape ecology, it became popular to equal spatial features with processes; so the presence of corridors was confused with connectivity, "a parameter of landscape function which measures the process by which subpopulations of organisms are interconnected into a functional demographic unit" (Baudry and Merriam, 1988). In fact, some species do not move outside a source patch even with a corridor, this has been shown for carabids (Burel, 1989) and plants (Baudry, 1989). Other groups do not seem to be affected by landscape structure (e.g. araneidae, Asselin and Baudry, 1989). Even if species move, the sink patch may not be suitable. So a good landscape structure is very much species specific.

* *fields and landscape:* Because the system they formed is hierarchical, one cannot make a sharp distinction between field and landscape level, as seen above for margins, size and shape. Landscape conditions change field characteristics that, in turn, change landscape structure. Succession increases connectedness among non agricultural patches (woodlots, old fields, moorland etc.).

* *human activity and landscape dynamics:* Knowledge of connections between the two are essential to understand and model ecological dynamics. This is the subject of part 2.

1.3.3. *Species characteristics*

As pointed out by Miles (1987) "in succession it is individual and populations that change". It is essential to know species colonization ability to predict trends in species composition. Characterization of succession by tree species can blur patterns because ground species disperse at a different rate. The choice of species to assess effects of abandonment is important.

From Miles statement, we conclude that it is misleading to view succession as the replacement of one vegetation unit by another. A species frequently associated with others may be absent because of the lack of source, its dispersal ability, landscape structure or within patch physical features. It is more important to make a classification of species according to their dispersal in specific landscapes (Bunçe and Howard, in press).

The spatial scale at which species react is another important factor. Some do react to changes on a few m^2 (eg. spiders), while others (birds) are only affected by changes on several hectares.

2. Prediction of trends in land use patterns

2.1. Position of the problem

The assessment of the positive and negative effects of land abandonment in the future can only be done at landscape and regional levels. Our models of prediction must include changes in land use patterns. These changes depend upon the hierarchy of agricultural systems within a region, which are driven by political and economical forces at higher levels (state, Common Agricultural Policy, GATT). This must tell us what type of land is likely to be abandoned in the (near) future and how it will be distributed in landscapes.

The first question to pose is "why is land abandoned?" Is it only because of field conditions? In this case maps of physical environment would provide most of the information needed to predict trends. In fact if it was so simple there would be no need to do research on this topic. Of course type of soil, slope, exposure, even accessibility, size, etc. are important, but their importance varies according to the type of agricultural system that characterizes the production unit the field is included in. The unit of production can be a farm, but could also be a village. Land is abandoned when the system is stressed by external forces or because of its own dynamics toward extensification or intensification, which is usually driven by economic conditions or the social environment. This is shown by the current situation (milk quotas, set-aside...), and by studies of older cases.

In this perspective the question becomes "why a farmer or a community of farmers decide to abandon a piece of land or an almost entire region?".

Case studies of land abandonment at the region levels are numerous in France. INRA-ENSAA (1977), Bazin *et al.,* (1983), Balent (1987), Hubert (this volume) are specially relevant to our meeting because they study the changes in agricultural systems, not only the history of the countryside.

It is useful to distinguish between land abandonment in the period where an increase of food production was needed and the current situation where abandonment is due to surpluses. Nevertheless recent history can provide a wealth of information on this topic and it would certainly be useful to reconsider those studies in the light of the new concepts outlined above. I did not do such a reassessment in this paper, but I will draw some principles from the research of Bazin *et al.,* (1983) in the Monts Dômes, located in the mountainous area of central France.

2.2. Principles from the Monts Dômes research

The altitude of the study area is between 650 and 1400 m, the growing season (mean daily temperature 5° C) varies from 5 to 7.5 months. The rural society was until World War I in villages, the agricultural land was partly private, partly common. Collective organization was rather strong. Each village had to produce its own cereals. The rest of the land was for grazing (mainly sheep) and hay production. The arable land was located on the flattest/warmest part of each village territory. The agricultural potential was a function of both its characteristics and those of the land of the whole village. So the cereals in one village could be at the same altitude as the grazing areas in the next one. Village, not field, is the proper scale at which land use could be understood. Another important feature of the village agricultural system are the flows of nutrients related to grazing and manuring: the tendency was to concentrate nutrients on arable land.

The system collapsed during World War I because the number of workers diminished during and after the war, this caused the abandonment of fields difficult to plough and, sometimes of collective grazing. This facilitated an increase in farm size. The war also increased the connection between the local, the regional, and even the national economy. In the meantime the production unit was more and more the individual farm, not the village; this pattern was also noticed by Balent (1989) in the Pyrenees. In conditions that Allen and Starr (1982) call collapse by overconnection, market conditions changed dramatically. Cereals from the valley became available and city dwellers started to appreciate the local cheese, favouring a change of farming system toward dairy production. This necessitated a better forage. Mechanization came along. Tractors can only be used on moderate slopes and large fields. Slopes were abandoned, but also the flat areas of good arable soils that had been previously divided into narrow (3 m) fields to give a good parcel to everyone. Extension of moorland, and coniferous woodlots was possible because of the integration of the local society into a higher level of the social organization (food and labour market and mechanization). The farmers took a different view at the local land resources. The causes of patterns and timing of land abandonment are to be found in the evolving interactions between the physical environment, a changing society, and new techniques.

2.2. Current changes

One of the objectives of the meeting is to address current patterns of change. Studies in the British uplands (Bell and Bunce, 1987) pose the problems of conservation under intensification and abandonment. Land use changes is a matter of research for economists (Boussard, 1988). Connections between the ecological, agricultural and socio-economic aspects are at the origin of a MAB proposal discussed later (Turenne, this volume).

3. Conclusion: agenda for the meeting

As ecologists, we can help to formulate goals and we can provide some answers. Certainly our greatest challenges are: how compatible are the different goals? and, what are the proper levels of ecological and social systems to act upon to attain these goals?

To design new research, it is necessary to:

* Assess the current knowledge on the consequences of land abandonment. Are there better alternatives from an ecological viewpoint, such as extensification?

* Identify methods of research available, their range of validity.

* List advice that can be given to policy makers, planners, land managers and farmers. How can we assist them in the definition of objectives?

* Identify areas of research to be developed.

* Create a dynamic for further research, and cooperation at the European level.

The discussion with the economists is an opportunity to clarify the type of work we can do together. Before such discussion, however, we must make clear what we want to know on land use patterns and what type of models are available to us.

* What type of information on land use do we need at different levels, from landscapes to EEC? At a landscape level we need a description of the dynamics of landscape structure. At regional level trends of areas of land cover types may be enough.

* Models are numerous and are often easy to run on computers. But "the most important present limit to the development of better models of landscape change may be a lack of knowledge of how and why the landscape changes, and how to incorporate such knowledge in useful models, rather than a lack of technology to develop and operate models of landscape changes" as pointed out by Baker (1989) in his review.

Are remote sensing data at an appropriate scale for any type of process?

To be useful, the cooperation with economists must not be addition of a bit of ecology in their models or a bit of economy in ours. We must be able to integrate our different concepts to answer the same question. What are the common questions? Can "land abandonment" be one?

Last, we must not forget to incorporate the farmers' practices and technical knowledge on agricultural systems in the models.

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References

ALLEN, T.F.H. and STARR, T.B. (1982): Hierarchy: perspectives for ecological complexity. The university of Chicago Press, Chicago and London, 310 pp.

ASSELIN, A. and BAUDRY, J. (1989): Les araneides dans un espace agricole en mutation. Acta Oecologica Oecol. Appli. *10*: 143-156.

AURICOSTE, C., DEFFONTAINES, J.P., FIORELLI, J.L., LANGLET, A. and OSTY, P.L. (1983): Friches, parcours et activités d'élevage: le cas des Vosges et des Causses. Institut National de la Recherche Agronomique, Paris, 55 pp.

BAKER, W.L. (1989): A review of models of landscape change. Landscape Ecology *2*: 111-133.

BALENT G. (1987): Structure, fonctionnement, et évolution d'un système pastoral. Le pâturage vu comme un facteur écologique piloté, dans les Pyrénées Centrales. Thèse de Doctorat d'Etat, Université de Rennes 150 pp.

BALENT, G. (1989): Hierarchical analysis of spatial patterns in pastoral systems. Etudes et Recherches sur les Systèmes Agraires et le Développement *16*: 187-198.

BAUDRY, J. (1989): Colonization of grassland under extensification by hedgerow species. Pages 765-774 in: Brighton Crop Protection Conference, British Crop Protection Council no 2.

BAUDRY, J. and BUREL, F. (1982): La mesure de la diversité spatiale: Utilisation dans les évaluations d'impact. Acta Oecologica Oeologica Applicata *3*: 177-190.

BAUDRY, J. and MERRIAM, H.G. (1988): Connectivity and connectedness: functional versus structural patterns in landscapes. Pages 23-28 *in*: Connectivity in Landscape Ecology (Schreiber, K.F., ed.). Proc. 2nd IALE seminar Münstersche Geographische Arbeiten 29.

BAZIN G., G.R. LARRERE, F.X. DE MONTARD, M. LAFARGE and P. LOISEAU (1983): Système agraire et pratiques paysannes dans les Monts Dômes. I.N.R.A., Paris, 317 pp.

BELL, M. and BUNCE, R.G.H. (eds.) (1987): Agriculture and conservation in the hills and uplands. NERC, Institute of Terrestrial Ecology, *23*: 164 pp.

BOUSSARD, J.M. (ed.) (1988): Agriculture: socio-economic factors in land evaluation. Commission of the European Communities, Report EUR 11269 en 203 pp.

BROUWER, F.M. (1989): Determination of broad-scale land use changes by climate and soils. J. Env. Manag. *29*: 1-15.

BROWN, V.K., JEPSEN, M. and GIBSON, C.W.D. (1988): Insect herbivory: effects on early old field succession demonstrated by chemical exclusion methods. Oikos *52*: 293-302.

BUNCE, R.G.H. and HOWARD, D.C. (eds.) (in press): Species dispersal in agricultural environments. Belhaven Press: Lymington.

BUREL, F. (1989): Landscape structure effects on carabid beetles spatial patterns in Western France. Landscape Ecology, *2*: 215-226.

BUREL, F., and BAUDRY, J. (in press): Hedgerow networks as habitats for colonization of abandoned agricultural land. *in*: Species dispersal in agricultural environments (Bunce, R.H.G. and Howard, D.C., eds.). Belhaven Press: Lymington.

BURGESS, R.L. and SHARPE, D.M. (eds.) (1981): Forest island dynamics in man dominated landscapes, Ecological studies *41* Springer Verlag, New York, Heidelberg, Berlin, 310 pp.

COX, G.W. and ATKINS, M.D. (1979): Agricultural ecology. Freeman W.H. and Company, San Francisco, 721 pp.

EGPN (1987): Conséquences écologiques de la déprise agricole et du changement d'affectation des terres; Séminaire de Florac, Avril 1987 Ministère de l'Environnement, SRETIE, Comité EGPN, doc poly 273 pp.

FORMAN R.T.T. and M. GODRON (1986): Landscape ecology. John Wiley and sons, 619 pp.

GOLLEY F.B. (1987): Introducing Landscape Ecology. Landscape. Ecology *1*: 1-3.

GOLLEY, F. and GOLLEY, P. (eds.) (1988): Environmental Consequences of Changing Agricultural Policy and Practice. Ecology International *16*: 75 pp.

GRAHAM, D.J. and HUTCHINGS, M.J. (1988): Estimation of the seed bank of a chalk grassland ley established on a former arable land. J. Appl. Ecol. *25*: 241-252.

GRAY A.J., CRAWLEY M.J., and EDWARDS P.J. (eds.) (1987): Colonization, Succession and Stability. Symposium of the British Ecological Society nº *26*, Blackwell Scientific Publications Oxford 482 pp.

GRYSEELS, M. (1989): Nature management experiments in a derelict reedmarsh 1: effects of winter cutting. Biological Conservation *47*: 171-193

INRA, ENSSAA (GROUPE DE RECHERCHE) (1977): Pays, Paysans, Paysages dans les Vosges du Sud. INRA, Paris, ENSSAA, Dijon 192 pp.

LOISEAU, P. and MERLE, G. (1981): Production et évolution des landes à callune dans la région des Dômes (Puy-de-Dôme): Acta Oecologica Oecol. Appli. *2*: 283-298.

LOWRANCE R., B.R. STINNER and G.J. HOUSE (eds.) (1984): Agricultural ecosystems. John Wiley and Sons. New-York. 233 pp.

MEEUS, J., VAN DER PLOEG, J.D. and WIJERMANS, M. (1988): Changing agricultural landscapes in Europe: Continuity, deterioration or rupture? IFLA Conference Rotterdam 104 pp.

MILES, J. (1987): Vegetation succession: past and present perceptions. Pages 1-29 *in*: Colonization, succession and stability (Gray, A.J., Crawley, M.J. and Edwards, P.J., eds.). 26th Symposium of the British Ecological Society. Blackwell Scientific Publications, London.

O'NEILL R.V., KRUMMEL J.R., GARDNER R.H., SUGIHARA G., JACKSON B., DEANGELIS D.L., MILNE B. and TURNER M. (1988): Indices of landscape patterns. Landscape Ecology *1*: 153-162.

PAOLETTI, M.G., STINNER, B.R. and LORENZONI, G.G. (eds.) (1989): Agricultural Ecology and Environment. Proceedings of an International Symposium on Agricultural Ecology and Environment, Padova, Italy 5-7 April 1988. Elsevier. The Netherlands.

THALEN, D.C.P., POORTER, H., LOTZ, L.A.P. and OOSTERVELD, P. (1987): Modelling the structural changes in vegetation under different grazing regimes. Pages 167-183 *in*: Disturbance in Grasslands (van Andel et al., eds.). Dr. Junk Publishers, Dordrecht.

USHER M.B. (ed.) (1986): Wildlife conservation evaluation. Chapman and Hall, New-York, London 394 pp.

WAY, M. and GREIG-SMITH, P.W. (eds.) (1987): Field margins. British Crop Protection Council. Monograph n.º *35*, 128 pp.