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Recent changes of the mosaic patterns in a montane landscape (north Italy) and consequences on vertebrate fauna

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SUMMARY - In north-western Italy, an area of 129,850 ha was analysed using a GIS and the landscape pattern was determined. Land abandonment in mountainous areas has increased landscape heterogeneity and has caused an increase in woodlands. The lowlands and coastal regions have been transformed into urban areas. These changes have influenced the vertebrate fauna in different ways. In the mountainous areas, conditions for wild boar and roe deer have improved, but for brown hare have declined. A large amount of information is available for the bird fauna. Birds respond to the landscape in different ways, depending on the species, time of year, and habitat. A land use trend toward increasing amount of forest and loss of riparian and marsh habitat will act negatively on the diversity of the bird fauna. A conservation methodology is proposed, which is designed to maintain a diverse landscape and provide corridors for animal movement between landscape elements.

Key words: Italy, Appennines, landscape, conservation, vertebrates, birds, patches, corridors.

RESUME - "Changements récents dans les modèles de mosaïque d'un paysage de montagne (Nord de l'Italie) et conséquences sur la faune vertébrée". Une zone de 129.850 ha du Nord-Ouest de l'Italie a été analysée par la méthode GIS, et les différents types de paysage ont été définis. L'abandon des terres dans les régions montagneuses a accru l'hétérogénéité du paysage et l'étendue des espaces forestiers. Les régions des plaines et du littoral sont devenues des espaces urbains. Ces changements se sont répercutés sur la faune vertébrée de plusieurs façons. Dans les montagnes, les conditions sont devenues plus favorables au sanglier et au chevreuil, mais plus difficiles pour le lièvre brun. Beaucoup de données ont été recueillies sur les oiseaux. Ces derniers sont influencés par le paysage de différente façon selon les espèces, la période de l'année, et l'habitat. L'une des tendances qui vise à l'augmentation des espaces forestiers et à la réduction d'habitat dans les marécages et les rivages aura des conséquences négatives en ce qui concerne la diversité de la faune ornithologique. Nous proposons ici une méthodologie pour la conservation d'un paysage diversifié, qui comprend également des couloirs permettant le mouvement des animaux entre les différents éléments du paysage.

Mots-clés: Italie, Appennins, paysage, conservation, vertébrés, oiseaux, patches, couloirs.

Introduction

In this last century deep changes of the landscape mosaic occured in many countries due to different anthropogenic causes as industrialization, urbanization, agriculture intensification, land abandonment, etc. The effects of these processes, involving energy I/O patterns, availability of resources, human migration, changes of land use and of environmental culture, have strongly affected the biological diversity (either by local extinction and/or geographical range reduction of rare species, or by thriving of some opportunistic species) with future impredictable consequences on many forms of life.

In front of a progressive fragmentation of the natural landscape in many developing regions of the world, an opposite trend is experienced in many parts of Europe, especially in rural mountainous landscape, recently abandoned by agricultural practices, with severe consequences on the vertebrate fauna. In order to investigate the effects of rural landscape changes on the vertebrate fauna it is

not possible to escape the role of human activity, at a historical temporal scale, as modeling the landscape structure and driving the dynamics of the related processes.

In fact, the current mosaic has been produced by different strategies of exploitation of a broad range of natural and seminatural resources, affected by historical events such as invasions, wars, famines and plagues. The causes of this abandonment and the consequential effects on vertebrate fauna are analyzed in a hilly and mountain area of north Italy in order to assess the natural and anthropogenic consequences on the rural landscape.

The study was carried out utilizing a landscape ecology approach. In fact, landscape ecology allows us to study the environmental problems occuring at large scale, providing a context in which to understand the role of the ecosystems (Golley *et al.,* 1989)

The study area

The study area, located in the north-western part of the Italian peninsula, along the Apennines mountains, may be considered a fine grained mosaic of cultivation and woodlots produced by the human activity dated back to the Paleolithic (Ambrosi, 1981).

At a broad geographical scale three main morphological elements are distinguishable in this area: the coastal plain, bordered by the Ligurian sea, in the western part, the Apennines chain in the middle part and the Padana valley in the eastern part. These three geostructural components have experienced different morphological patterns:

1. stream and river erosion in the Apennines;

2. river and sea sedimentation in the coastal plain;

3. river sedimentation in the Padana valley;

4. big development of urbanization and intensification of agriculture in the plains;

5. emigration and abandonment of cultural practices in rural montane areas.

The study area, 129,850 ha, coincident with the political boundaries of the Massa Carrara Province, occupies the western part of the Appennines, namely the Magra river watershed and the upper part of the Versilia coastal plain. This area may be divided in five physiographic sub-regions: the coastal plain, the Alpi Apuane mountain chain, the Ligurian Apennines, the graben of the Magra river and the Tosco-emiliano Apennines (Fig. 1). The area is subjected to the juridiction of 17 communes, in two of these, Carrara and Massa, is concentrated more than the 80% of the entire provincial population.

Methods

The landscape information was collected using a Geographic Information System (G.I.S.) with a raster system (Burrough 1986, Bartlett 1987) composed of 28,463 land units (LU) of 4 ha each. The data collected for each LU consist of morphological attributes (height, slope, exposition) and of land use types according to the standard of the Tuscany Regional Government that distinguishes 53 types at all (Giordano *et al.*, 1986). The scale of 4 ha appears sufficiently fine for the computation of animal predictive models. A G.I.S. describing the rural Mommio community in the Fivizzano commune and composed of 6,186 land units (LU) of 0.4 ha each, was used to describe the cadastral patterns of a typical montane rural community.

The main landscape attributes were described by the diversity, dominance and contagion indexes (O'Neill *et al.*, 1988, Turner and Ruscher 1988) applied to the current and to a past landscape, dated between the first years of this century, sixty years later and a future probable landscape dated in the next thirty years (Farina, 1989b).

The information on the fauna was based either on occasional observations that I collected in many years of field work for the Museum of Natural History of Lunigiana (Farina 1980), or during specified research on distribution of micromammals (Graf *et al.*, 1979, Santini and Farina 1979, Farina and Cenni, 1983, Farina *et al.*, 1986) and birds. For this last group long term studies were carried out at a community level (*sensu* MacArthur 1971) in the most representative habitats. The evaluation of the habitat suitability for medium and large mammals was made using simple models based on the morphology (altitude, slope, orientation), land use (53 types) and level of anthropization (distance from urban area) (Farina, 1989c).

Climate and vegetation

The complex morphology and the presence of high mountains (2000 m the highest peak, not far from the sea, produce many microclimatic regimes ranging from the true Mediterranean to the Alpine (Bigi and Rustici 1984), supporting four main types of vegetation (Ferrarini 1972, 1979, 1981, 1989).

Along the coastal hills, a residual Mediterranean maqui degraded by fires is present. The interior (hills and low mountains) is covered by a mesophitic woodland, dominated by *Quercus pubescens, Q. cerris* and *Ostrya carpinifolia.* On the mountains between 900 and 1700 m the woodland is dominated by *Fagus sylvatica.* Above the tree limit (1700-1800 m) a narrow stripe of secondary mountain pastures and moorlands cover the

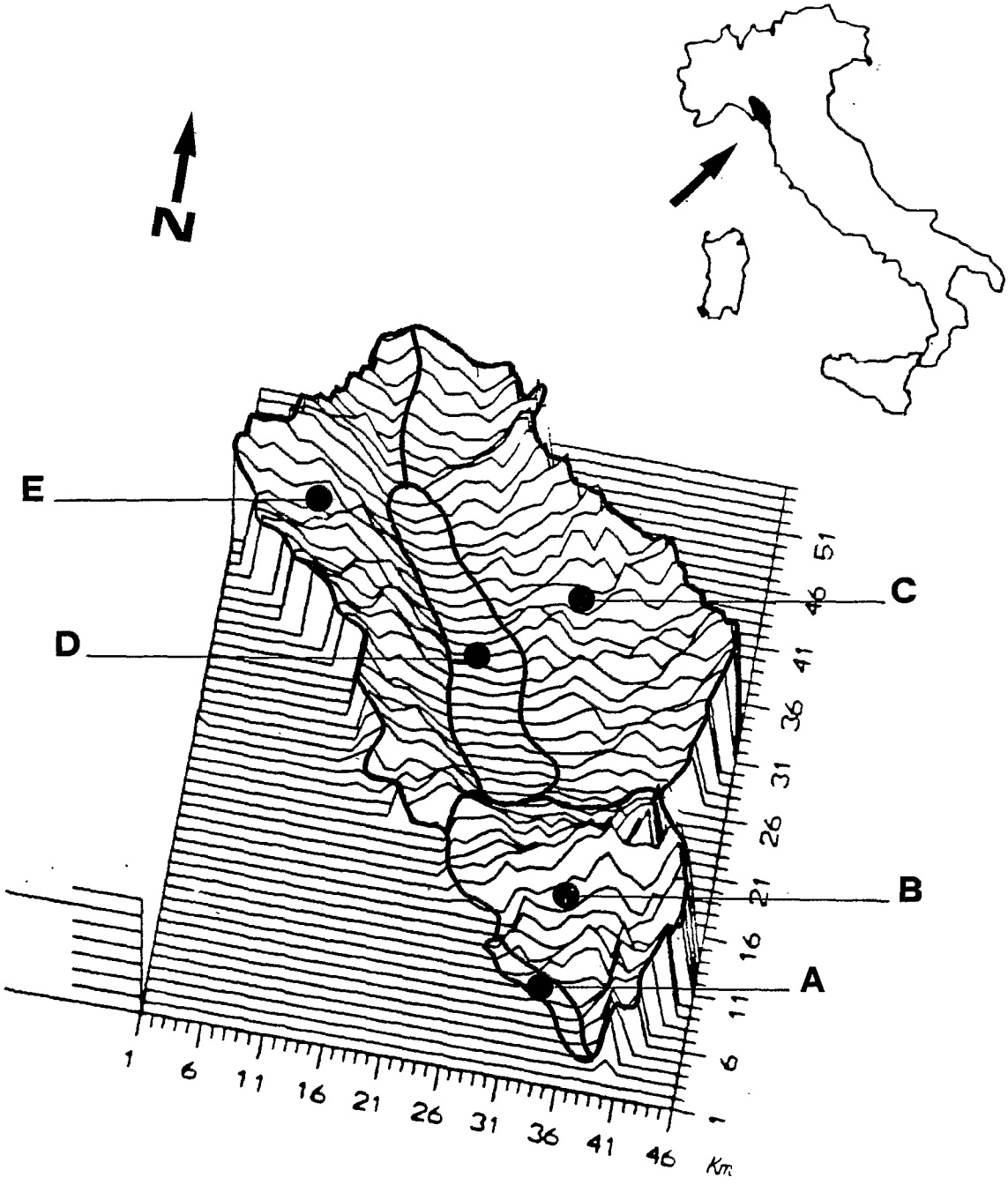

Fig. 1. - The three-dimensional surface representation of the study area (Province of Massa Carrara):

a. Coastal plain;
b. Alpi Apuane mountain chain;
c. Tosco-Emiliano Apennines;
d. Graben of the Magra river;
e. Ligurian Apennines.

mountain tops south-west and north-east facing respectively. This vegetation is composed by a rich variety of exigent, endemic and rare floristic elements (Ferrarini 1979, Ferrarini and Alessandrini 1989).

Main character and historical evolution of the landscape

The rural landscape before the recent modification was characterized by:

1. farmlands composing the landscape matrix;
2. a spread terracing on the steepest slopes;
3. a fine grained divisions in small properties (from 1 ha to 10 ha) (Fig. 2).

The landscape was divided among well delimited rural communities generally disposed along a broad altitudinal range. The Mommio community is a significative example of montane rural community ranging from 500 to 1900 m a.s.l. Using as an example the intensity and shape of cadastral divisions of this rural community as index of cultivation spatial patterns it is possible to distinguish different land uses according to elevation and slope inclination (Fig. 3, 4).

The most significative changes of the landscape date back from the end of the 19th century and the beginning of the 20th. Beginning from the first years of this century a strong emigration has produced a decrease of population in the mountain areas toward foreign countries and lowlands. The emigration was very strong especially in the montane communes (-59% in Bagnone and -52% in Zeri between the 1861 and the 1981 period). On the contrary the low land coastal communes (Massa and Carrara) have experienced a spectacular increase of population (329% and 305% respectively) between 1951 and 1981 (Table 1). Contemporarily the number of people working in the agriculture decreased dramatically (f.i. in the Zeri commune the importance of workers in agriculture fell from 89 to 33% of the total labor force between 1951 and 1981 (Table 2).

The abandoned lands are quickly revegetated by a mosaic of shrubs and woodlots with different level of degradation due to fires, grazing and loggings. The speed of recovery of natural vegetation into the abandoned croplands is high. Ferns (*Felce aquilina), Prunus spinosa, Crataegus monogyna, Rubus* sp, *Rosa canina, Sarothamnus scoparius, Erica arborea and Juniperus communis* are the commonest invading shrubs.

Table I. Population differences (in percent) in the 1861-1951 period (a) and in the 1951-1981 period (b) (data source from ISTAT - Roma).

Commune	A	b
Aulla	0.02	1.01
Bagnone	–.59	–.56
Carrara	0.10	2.75
Casola	–.44	–.46
Comano	–.46	0.00
Filattiera	–.39	0.22
Fivizzano	–.34	–.29
Fosdinovo	–.12	–.19
Licciana	–.15	0.27
Massa	0.30	3.29
Montignoso	0.43	3.05
Mulazzo	–.38	–.36
Podenzana	–.22	–.14
Pontremoli	–.30	–.18
Tresana	–.45	–.32
Villafranca	–.15	0.28
Zeri	–.52	–.50

Table II. The percentual importance of workers in agriculture along the last forty years (data source from ISTAT - Roma).

Commune	Years			
	1951	1961	1971	1981
Aulla	0.35	0.18	0.11	0.06
Bagnone	0.37	0.27	0.24	0.16
Carrara	0.04	0.02	0.01	0.01
Casola	0.50	0.32	0.29	0.13
Comano	0.29	0.32	0.41	0.29
Filattiera	0.49	0.33	0.26	0.14
Fivizzano	0.44	0.26	0.19	0.14
Fosdinovo	0.61	0.41	0.21	0.10
Licciana	0.50	0.28	0.17	0.11
Massa	0.09	0.05	0.03	0.02
Montignoso	0.17	0.08	0.05	0.02
Mulazzo	0.58	0.39	0.30	0.15
Podenzana	0.43	0.38	0.22	0.04
Pontremoli	0.42	0.23	0.17	0.09
Tresana	0.57	0.36	0.33	0.13
Villafranca	0.32	0.20	0.12	0.06
Zeri	0.89	0.45	0.52	0.33

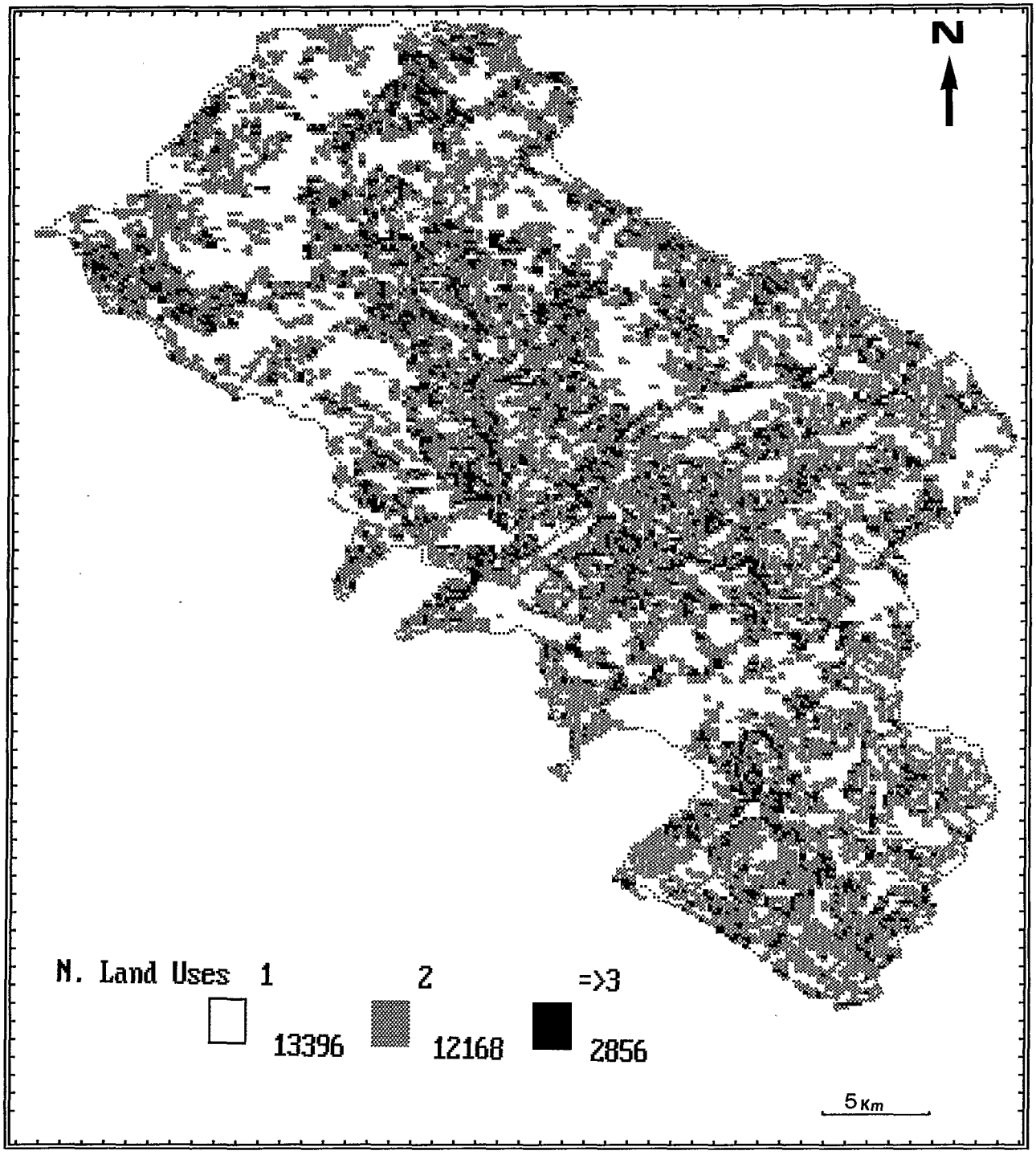

Fig. 2. - Land units of the Massa Carrara Province emphasizing the fine grained division of the land according to the number of cover types per land unit (200x200 m).

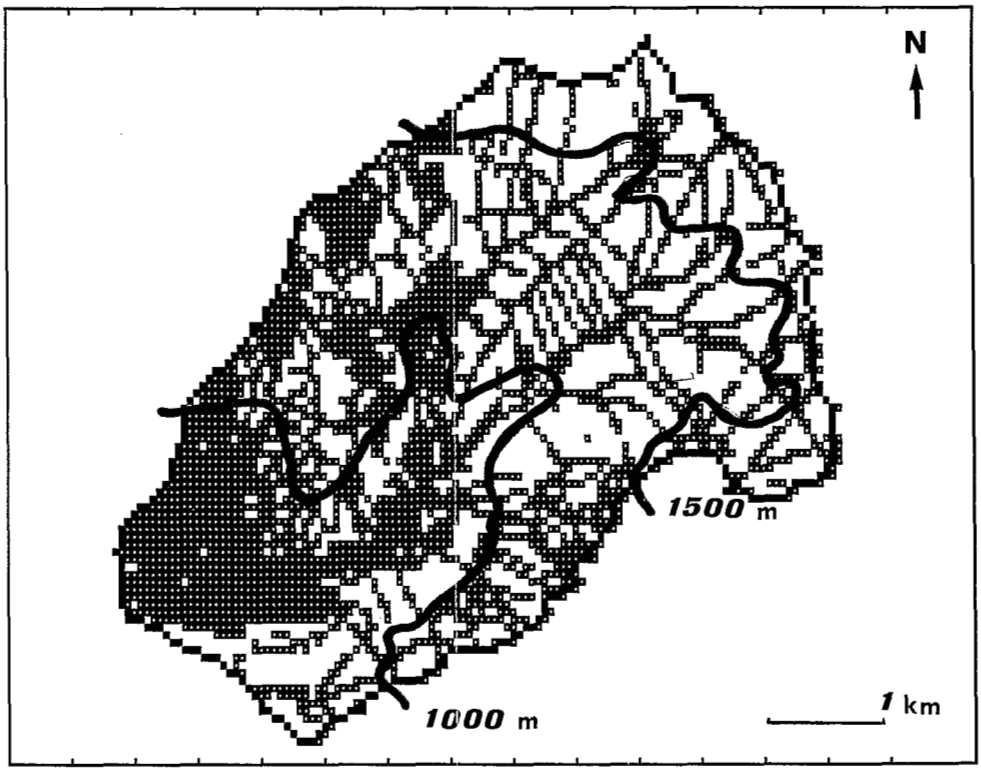

Fig. 3. - Cadastral divisions of the Mommio rural community. The black cells indicate the presence of at least one boundary subdivision of land. The isoypses of the 1000 and 1500 meters are superimposed.

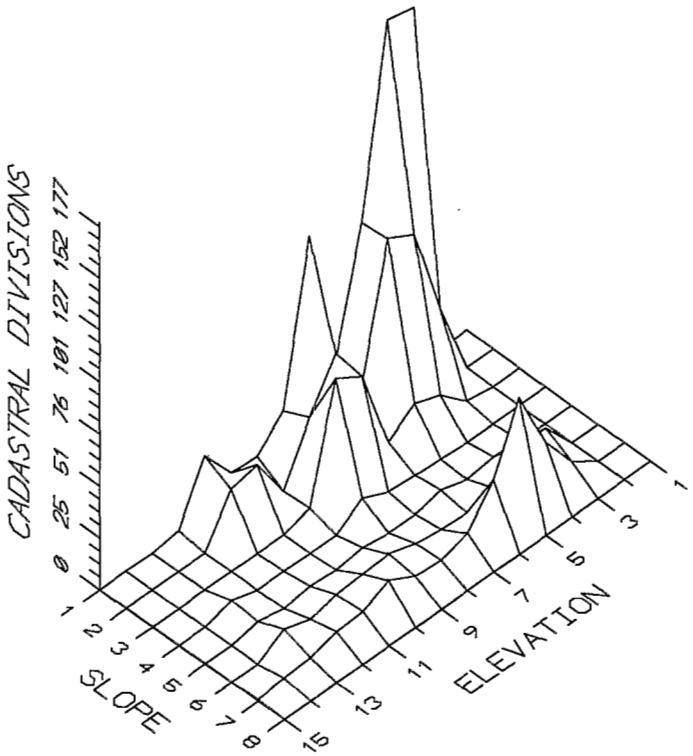

Fig. 4. - Ordination of cadastral divisions (z axis) of Mommio rural community according to slope orientation and elevation categories:
Elevation categories (1=<500, 2=500-600, 3=600-700,.... 15=>1900 m);
Slope inclination categories (1=south, 2=south-east, 3=east, 4=north-east, 5=north, 6=north-west, 7=west, 8=south-west)

These changes have produced:

1. the reduction of the agriculture practices in the hilly areas,
2. the abandonment of agriculture in coastal and low land plains,
3. the transformation of many arable fields in pastures,
4. the reduction of cattle rearing,
5. the reduction of chestnut orchards,
6. new, more destructive, broad scale logging.

In the hilly areas the agriculture remains but with low levels of productivity mainly consisting in wine and olive harvests. The recent evolution of the landscape may be distinguished in two periods:

1. from the end of the second World War to 1970; in this period landscape diversity, computed using the land use, the dominance (the relative importance of each land use) and the contagion index (the measure of interconnectivity between patches with different land use) increase (first stage of abandonment of many cultivated lands, changes from cultivation to a woodland matrix);

2. from the 70's until today landscape diversity and contagion is reduced and dominance increases (Table 3). This is a common trend along the Apennines (Van Der Berg *et al.*, 1988);

Table III. Indexes of landscape pattern long the last forty years (H'= diversity, D=dominance, C=contagion, see text).

	1950	1975	1990
H'	2.36	2.74	1.87
D	1.18	1.22	1.78
C	184	300	220

The abandonment of agriculture has produced an increase in the mosaic homogeneity, the opposite effect of the past, and the diffusion of woodlands. Apparently the montane pastures located above the tree level (1700-2000 m) maintain a similar aspect despite a change in grazing sheep pressure. Recent burning, repeated annually, is producing degradation effects on the flora. The coastal plain and the lowlands have been transformed into urban areas, with a complete loss of the agricultural land use.

The effects of landscape patterns on the fauna

It is important to emphasize that the fragmentation of this region has not been produced by human activity in a short time but probably is the result of a progressive anthropization started with the expansion of Roman Empire and comprehensive water management, wood cultivation and slope terracing. The animal populations probably experienced a coadaptation to these landscape processes although is speculative to discuss the composition and the dynamics of the past fauna. In the past the prevalent landscape matrix was composed by cultivated fields, and many forest species that needed wide wooded stands disappeared. Others were persecuted because they conflicted with livestock. The bear (*Ursus arctos*) disappeared at the beginning of the 18th century, and the wolf (*Canis lupus*) was probably locally extinct at the end of the 19th century. With the increase of forest fragmentation, habitat generalists and opportunistic species replaced gradually the more exigent inner forest species.

The fish populations have been affected for a long time by human fishery (collective fisheries), but in spite of this, today the fish stock is well distributed along streams and rivers (Farina, 1981a) and habitat exigent species, as *Gasterosteus aculeatus* and *Lampetra fluviatilis* can be found in many sites. In recent years the human disturbance on riparian habitat is increasing due to gravel mines. This disturbance has produced a simplification of the morphological and functional riparian mosaic.

The frequent occupation of the lands near the rivers by roads has negatively influenced the distribution of species sensible to human presence, such as the otter (*Lutra lutra*) which has disappeared in these last twenty years (Beseghi 1988, Cassola *et al.*, 1988).

One of the most evident effect of landscape changes has been the recent abundance of the wild boar (*Sus scrofa*) and the roe deer (*Capreolus capreolus*). These two species have been extinct in this area from many centuries, but were reintroduced twenty years ago. The wild boar is becoming a true pest in spite of a high human hunting pressure. The diffusion of these two species probably is related to the abundance of food resources in abandoned fields and to the change of landscape matrix (*sensu* Forman and Godron 1986) from fields to woods as consequence of land abandonment. The crested porcupine (*Histrix cristata*) is a species which has recently appeared in the region. Probably this diffusion depends not only on landscape changes but on other factors as well, such as the genetic control of the populations. The wolf is in expansion along the Apennines and it is probable that some individuals can be present in the more remote patches of the study area.

During the 60's-70's with the expansion of the hunt as a "recreational activity", the use of poisons against Mustelidae and foxes have affected tremendously many medium size mammals. Today severe laws protect most of the mammals and an expansion of weasel (*Mustela nivalis*), beech marten (*Martes foina*), and badger (*Meles meles*) is in progress. Feral cats and dogs are becoming very common, favoured in their expansion by the abundance of edible wastes. In many cases, dogs produce locally damages on sheep and on introduced game species (*Phasianidae* and *Lepus* sp.).

The increase of woodland connectivity probably has favoured the spread of the large and medium mammals although human barriers as roads and highways, when combined with natural barriers (rivers, mountain slopes), represent severe obstacles to mammal diffusion. For example, the roe deer is present only in the left part of the Massa Province and is absent on the right side separated by a highway, two main roads and by a railway, all running parallel along the Magra river bed.

Predictive species-specific models based on the coupling of species-specific habitat requirements with the GIS information of Massa Carrara Province show high land suitability for wild boar and roe deer, and low land suitability for brown hare (*Lepus capensis*) (Fig. 5).

Insular effects are expected on populations of *Microtus nivalis*, a species living above tree level in montane pastures and moorlands (Farina and Cenni, 1983, Farina *et al.*, 1986), due to the spread of wood cover. In the past the open agricultural matrix probably has favoured the presence of micromammals species as *Pytymis savii, P. multiplex* and *Suncus etruscus*) and of many species of bats. Especially for this last group, the occasional observations of speleologists at the end of the 19th century confirm the current reduction while other species as edible dormouse (*Glis gliris*), red squirrel (*Sciurus vulgaris*) and dormouse (*Muscardinus avellanarius*) are favoured by the recent shrub and wood diffusion.

Much information is available on birds due to long term studies on the composition and dynamics of many bird communities (Farina 1980, 1981a, 1981b, 1985, 1986, 1987, 1988a, 1988b; Farina *et al.*, 1989) (Table 4) although in some cases it is difficult to transfer this information from the habitat scale to the landscape scale due to the census methodology adopted (f.i. line transects and point counts carried out in homogeneous habitat patches). The study area represents a favourable area for the breeding, wintering and stop over of many long distance migratory birds (Farina 1987, 1988a, 1989b; Farina *et al.*, 1989).

It is possible to classify the birds into five main phenological categories:

1. permanent resident,
2. spring migratory transient,
3. autumn migratory transient,
4. north European wintering,
5. summer migratory breeder.

From the data available, it is also possible to classify the different patches of the landscape mosaic into those with low bird turnover (woodlands, urbans) and those with high seasonal turnover (farmland and riparian shrubland). Farmland and riparian are habitats also characterized by high density of migratory stop overs.

Table IV. Number of birds breeding in the study area(N), of birds breeding in the West palearctic (Ne) and the percent of all species of the West Palearctic breeding in the study area ordinated per families.

non-Passeriformes	N	%	Ne
1 Accipitridae	1	(3.5)	28
2 Falconidae	2	(20)	10
3 Fasianidae	1	(14)	7
4 Charadriidae	2	(22)	9
5 Columbidae	1	(17)	6
6 Apodidae	1	(25)	4
7 Alcedinidae	1	(100)	1
8 Cuculidae	1	(50)	2
9 Upupidae	1	(100)	1
10 Picidae	2	(20)	10
Passeriformes			
1 Alaudidae	1	(12)	8
2 Hirundinidae	4	(80)	5
3 Motacillidae	5	(62)	8
4 Cinclidae	1	(100)	62
5 Troglodytidae	1	(100)	1
6 Prunellidae	2	(100)	2
7 Turdidae	10	(45)	22
8 Sylvidae	14	(39)	36
9 Muscicapidae	1	(25)	4
10 Aegithalidae	1	(100)	1
11 Paridae	4	(40)	10
12 Sittidae	1	(25)	4
13 Certhidae	1	(50)	2
14 Remizidae	1	(100)	1
15 Oriolidae	1	(100)	1
16 Laniidae	2	(40)	5
17 Corvidae	2	(16)	12
18 Sturnidae	1	(33)	3
19 Passeridae	2	(40)	5
20 Fringillidae	2	(40)	5
21 Emberizidae	2	(15)	13

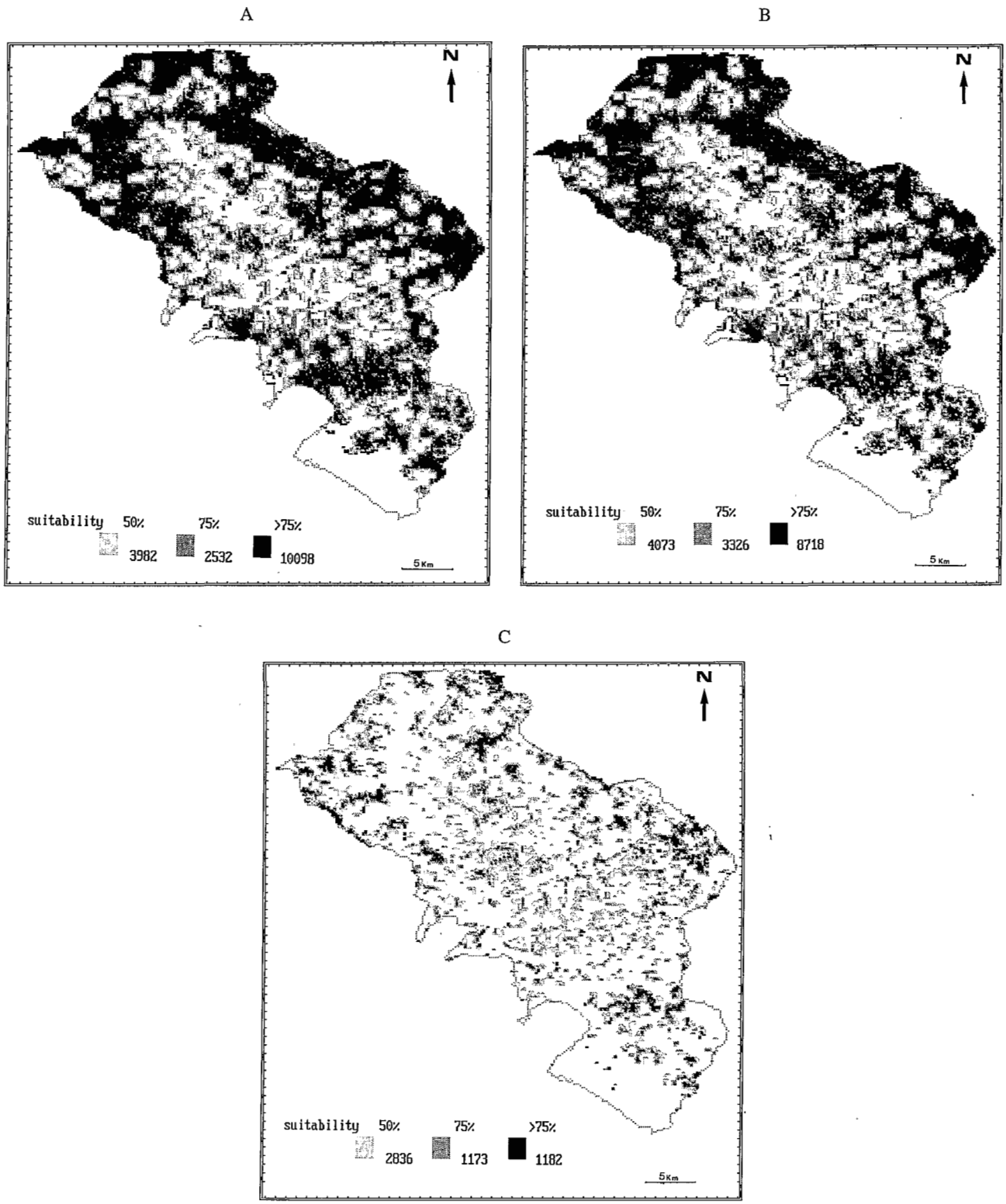

Fig. 5. Land suitability model for: a. Wild Boar; b. Roe Deer; c: Brown Hare. (from Farina 1989c) unpubl. technical report)

A common character expressed by the bird communities in each of the patch habitats of this complex land mosaic is the singularity of each bird community in spite of the homogeneity of the component patches at a mesoscale. For example the secondary montane pastures have distinct bird populations with respect to other habitats, but when different pastures are compared, a low affinity among these site is found (Fig. 6). Probably these habitats are affected not only by the interior habitat structure but also by the bordering habitats, the morphological and climatic location, and the recent evolution of each habitat in terms of human and livestock grazing pressure.

In the past, these habitats were used as crop fields and today are grazed at different levels; they play an important role for many species of transient and wintering birds. The bird communities here are characterized by high inter-seasonal turnover and many birds recorded are not true habitat specialists. For example, tits are common visitors in autumn, and the robin and wren are common in winter and early spring. Different foraging guilds exploit these man made habitats. In spring insectivorous guilds prevail, in autumn and winter granivorous and frugivorous guilds. During the winter period when the weather is fine and windless, the secondary mountain pastures experience a temperate climate due to the temperature inversion effect. During this phenomenon an altitudinal migration from the plains up the mountains by insectivorous and frugivorous birds is observed. In spite of the reducing surface, these habitats play an important role for many metapopulations. Similarly great importance is represented by the riparian habitats in the rural landscape.

The river beds, although reduced and severely disturbed, support a rich bird fauna especially out of the breeding season. Rare, endangered and habitat exigent birds can be found. Four main foraging guilds are present: piscivorous, granivorous, frugivorous and insectivorous.

This habitat experiences a high spring impact of foliage gleaner birds during the spring migration, due to the early leafing of *Salix* sp. and to favourable microclimate during unfavourable days. In autumn the seeds of many pioneering plants attract frugivorous migratory birds. In winter this habitat rarely has a severe microclimate, becoming a refuge during the coldest days for many birds such as pipits, thrushes and warblers (Fig. 7).

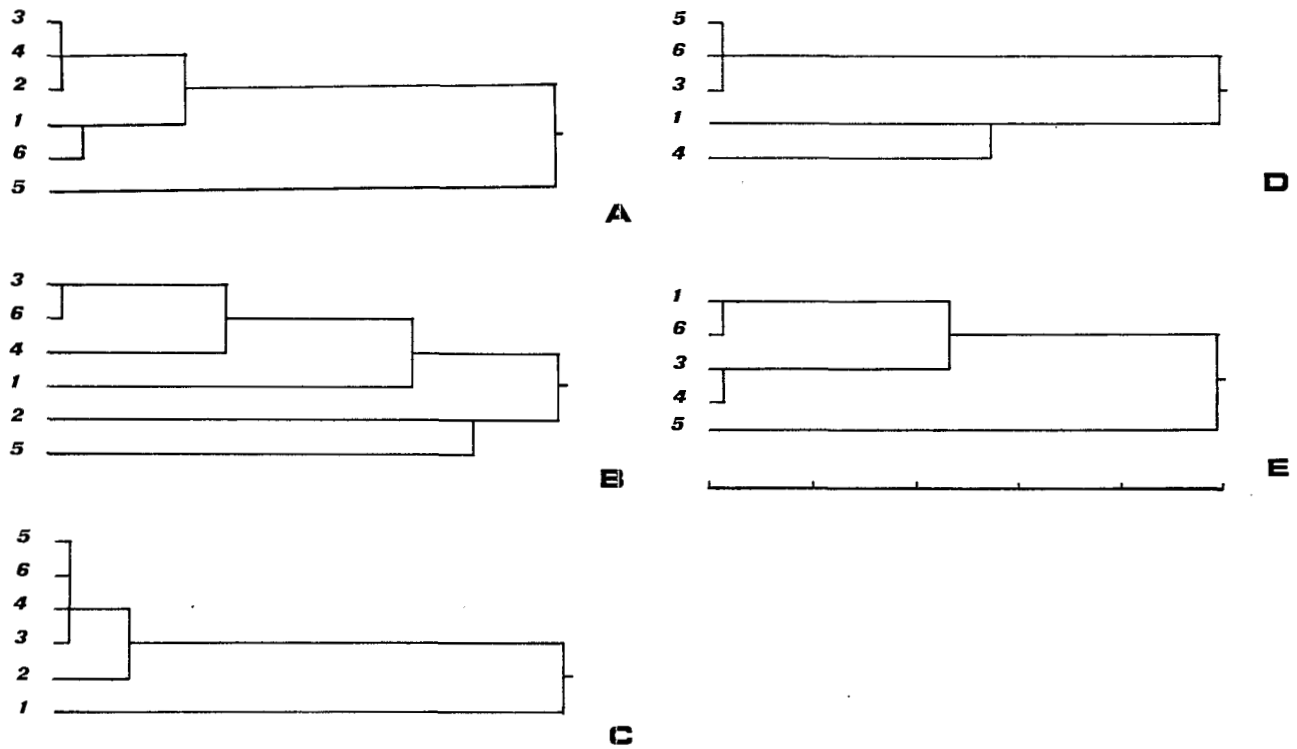

Fig. 6. - Ordination of bird communities according to the relative importance of Motacillidae, typical species of montane pastures, long a bimonthly interval (1-January/February, 2-March-April, 3-May/June, 4-July/August, 5-September/October, 6-November/December) in five selected montane pastures (a-Comano, b-Logarghena, c-Zeri, d-Varese.1, e-Varese.2)

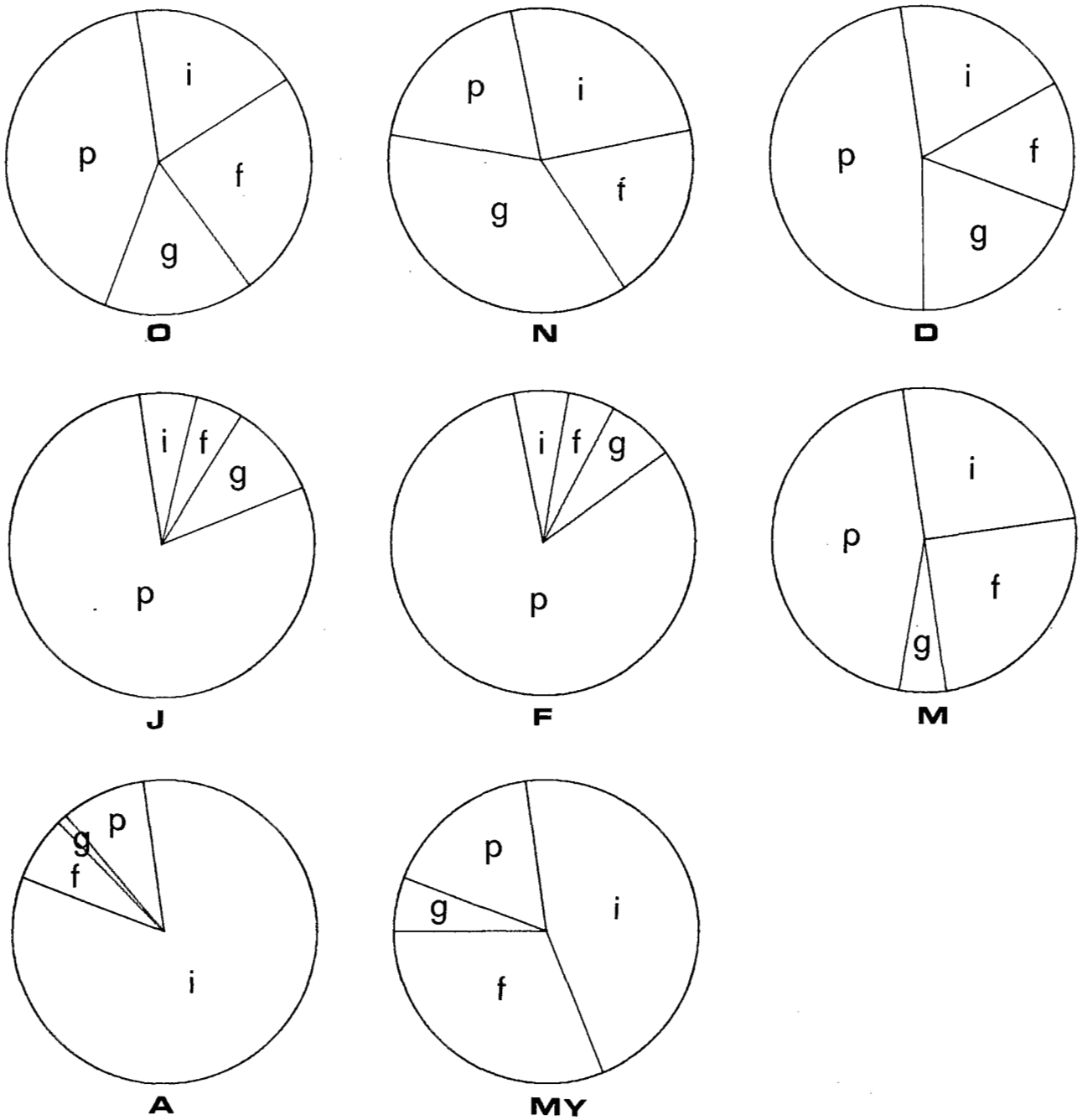

Fig. 7. - Relative importance of the main foraging guilds out of the breeding season of the bird community in riparian habitat (O,N,D,J,F,M,A,MY= months) from October to May.

Olive orchards are the preferred habitats for many wintering frugivorous birds, favoured also by the warmer microclimate present in these man made habitats. In seasons with high olive production it is possible to find large concentration of thrushes, warblers and finches. An important role during the winter is played also by the mixed croplands forming a very heterogeneous mosaic of temporarily cultivated patches supporting many species of birds (Farina, 1986).

The reduction of rural areas has serious effects on the structure and dynamics of many bird populations. In fact if the current trend of rural reduction and wood recover is maintained, we can expect in the next years a reduction in bird diversity with severe consequences,

especially on the migratory components of the bird fauna (Farina 1989b). It is well documented that structurally dense woodlands are avoided by species of birds (Ferry and Frochot 1970).

Discussion

The study area is a very complex environment. During these last decades the area has experienced deep changes of the landscape structure and function due to abandonment of the agricultural practices in the Apennines and the urbanization and the industrialization in the coastal and interior plains. The transformations of the landscape due to change of the land use have strongly affected the animal populations. In many cases these effects are not predictable due to the singularity of the phenomenon and as a consequence it is difficult to utilize planning tools valid for all purposes due to the high number of variables, factors, and patterns to be considered.

In the research for suitable strategies for the conservation of the biological diversity many abiotic, biotic and anthropogenic factors must be considered. I believe that in the studied region, where the human influence has lasted for millennia, it is impracticable in the short and medium time to change the geographical characterization of the study area that was supporting a good level of biological diversity. This strategy must be considered valid only at local scale. For instance, in a neighbouring area along the Thyrrenean coast, the reclamation of the original marshes and riparian habitats could be a most successful strategy.

The study area, for example, contrasts with habitats of the Padana valley and the connection with other seminatural areas is possible only along the Apennines. For many less vagile and habitat exigent species, the Apennines mountain chain becomes a true habitat island. In this case we cannot expect recolonization of extirpated species in a short time. For birds the insularity effects are less evident, but in many cases the occupation of a habitat depends on factors linked to biogeographical patterns.

In spite of the impossibility of managing the entire region at a microscale, at a mesoscale level it is possible to make general suggestions as:

1. Maintain marshes and riparian habitats. In fact, these habitats also support in small areas a rich fauna, especially birds, during important periods of the life cycle.

2. Maintain the hilly rural mosaic. These habitats have a warmer microclimate and the intense terracing represents rural patches of high cultural value, rich in resources available to many animals thanks to a human input seasonally synchronized with relevant phenological events, as bird migrations.

3. Favour the recovery of montane woods. The montane woodlands represent the connectivity along the Apennines and allow the presence of inner forest species and large mammals.

These three suggestions are compatible with the current trend in the human dynamics in this region.

Methodologies suggested

To manage abandoned rural areas it is important to follow the integrated steps listed below:

1. review of the historical processes experienced by the landscape at the suitable scale. In the present study the Mommio community appears a true subregion to manage as a unit of the overall landscape,
2. assessment of the current trend,
3. predict the future trend,
4. use of the largest quantity of information,
5. organize the information according to a spatial matrix,
6. verify the evolutional processes of the system,
7. compare planning strategies and landscape features.

In the study area a great quantity of analytical information is available, but to manage the rural landscape it is necessary that part of this information be transposed in a spatial dimension and that the anthropization trend be predicted by good indicators.

The role of many Mediterranean landscapes should be reexamined in order to assess the real importance of this region for the dynamics of many bird populations.

A landscape classification according to the more important patterns could be a primary goal for the future years. The classification of the landscapes is linked to the inter-regional and inter-state exchange of information. This is fundamental for the conservation of rare or endangered species. The study of the landscape mosaic is becoming very important thanks to numerous studies that have stressed the role of fragmentation, patch shape, patch dynamics for the movement, reproduction and survival of many types of animals (Mooney and Godron 1983, Swingland and Greenwood 1984, Naveh and Lieberman 1984, Pickett and White 1985, Forman and Godron 1986, Turner 1987).

The most common conservation strategy of the past years has been subordinated, in many cases, to the avail-

ability of a large extent of natural habitats. This strategy appears difficult to replicate in the Mediterranean region in which large size natural habitats are rare. Different strategies are necessary, for example considering north American recommendations (Harris 1984, Robbins *et al.*, 1989). For this purpose the landscape ecology approach could be important (Golley, 1989). The Mediterranean is a historical fragmented landscape in which human pressure is not destructive, although it conditions the animal populations. The management at a landscape mesoscale (farmland communities) could be the best approach for recovering and connecting many small size, dispersed and disturbed natural and seminatural habitat patches, increasing the connectivity among the animal metapopulations. The approach at this scale could allow us to utilize, in the opposite way, the strategies of resource exploitation used by farmers in the past. The remnant natural sites are located at the periphery of each farmland community and recovery could start from this position, with centripetal direction centered on villages. This suggested strategy can be successfully adopted only after a good assessment of the natural and anthropogenic patterns on a landscape, and in many cases it must be modified according to the characteristics of each regional landscape.

For many European countries the singularity of landscape patterns at a microscale reflects the singularity at a mesoscale, and consequently, it becomes very difficult to find common strategies. For instance, the English farmlands also show a very low level of natural changes during the phase of abandonment (Bunce, this symposium) and this differs completely from the Italian situation in which abandoned fields are quickly invaded and transformed by forbs and shrubs in few years.

Also the scale of the landscape mosaic appears a factor to keep in mind. In Spain, farmlands are in many cases characterized by large extension of cultivation in a homogeneous landscape with a very low human presence outside of the agricultural work. Probably the abandonment of this type of farmlands produces an increase of animal diversity (Fdez. Ales, in this symposium) due to the increase in the landscape heterogeneity.

In conclusion, at a European scale the landscapes are so different and have been so differently utilized by the man in the past that it becomes difficult to find common strategies of land and biodiversity conservation. A common philosophy should be to maintain the highest value of the cultural landscape, because in many cases, but not in all, it is synonymous with optimal biodiversity.

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