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Landscape-level diagnosis of ecological consequences of land abandonment in an uplands district (Hermillon, Savoie, France)

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Abstract : Many upland villages today are faced with a rapid afforestation of former fields and pastureland. This phenomenon leads to various problems concerning biological conservation and environmental quality. This paper presents a landscape-scale method for diagnosing biological richness and above all its evolution in this context of afforestation. Three approaches are used: a naturalist approach to determine the actual potential biological richness (in terms of both species richness and species quality), a spatial approach to des-

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Keywords : upland, land abandonment, afforestation, biodiversity, environmental quality.

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The second half of the 20th century was marked by significant changes in agricultural practices in France. In the major farming regions, agriculture intensified, while in the less favoured farming regions, a rural exodus led to the abandonment of agricultural and pastoral practices. Mountain areas were particularly affected by the rural exodus and recent decades have seen a rapid increase in wooded areas resulting from an anarchical and rapid re-colonisation of former farmland.

This issue started to be addressed by researchers in France in the 1980s, namely through the Environment Ministry's research programmes « Conséquences écologiques de la déprise agricole » (1987) (Ecological consequences of agriculture decline) and « Fermeture des paysages et modifications de la diversité biologique » (1999) (Closing-in of agricultural landscapes and modifications in biological diversity), the aim of which was to gain insights into the impact of these changes on ecosystems (Delcros, 1999). Thus, numerous studies have examined post-agricultural plant dynamics in areas of hedgerow networks and pastureland (bocages) (Gloaguen *et al.*, 1994 Burel & Baudry, 1995; Diquelou, 1997), in Mediterranean regions (Tatoni, 1992; Trié *et al.*, 1996; Le Floc'h *et al.*, 1998) and mountain regions (Doche, 1986; Dasnias, 1987; Muller, 1992; Delcros, 1993; Vanpeene-Bruhier, 1998).

Local rural communities concerned about the closing-in of their agricultural landscapes can henceforth legitimately expect scientists to provide them with more precise answers to their questions about natural risks, impacts on the landscape and the evolution of the biological heritage.

This is particularly the case of the Hermillon district, in the Moyenne-Maurienne area of Savoie. Here, cultivated land and pasture has shrunk by two thirds since 1901, and by nearly one half since 1956. As the woodland has gradually become more dominant, the changing landscape has given rise to a number of issues concerning not only the local population of Hermillon, who would be happier with another type of landscape, but also the image of the commune for outsiders, situated as it is on the slopes of a valley which is negatively perceived because of its industrialisation. Faced with this situation, the municipality of Hermillon called on the Cemagref in Grenoble (Piedallu *et al.*, 1997) to:

- conduct an assessment of landuse, floristic and faunistic diversity, and especially the potential evolution of these features in the event of the area being taken over by woody vegetation;
- heighten awareness among local residents of the issues at stake, and get them more involved;
- draw up a list of measures that can be taken to limit the risks relating to the expansion of the forest.

The aim of this article is to present the underlying logic of our method, which is based on the concepts of landscape ecology and governed by time constraints and the limited financial means of this small upland community ; to demonstrate how the method can provide input for land management decisions which satisfy both the wishes of the local population and the need to preserve the area's biological heritage.

Study area

The district of Hermillon (520 inhabitants in 1999) covers some 1,400 hectares, and is located on the adret slope of the Arc valley, in the Moyenne-Maurienne region, near Saint-Jean-de-Maurienne. Being south-facing, the valley-side enjoys a dry climate. Hermillon saw a substantial decline in the number of farms during the second half of the 20th century.

The survey site selected for this study, and approved by the municipality, is an area of 237 hectares around Hermillon and, higher up the slopes, around the hamlet of Montandré. The zone lies at an altitude of between 500 m and 1 250 m and essentially concerns sectors that have been most affected by farmland abandonment (Figure 1).

General Methodology

The methodology used was based on three parallel approaches (Diagram 1).

SPATIAL APPROACH

The aim was to identify the major landuse changes occurring during the 20th century, by quantifying them and determining their spatial distribution. Landuse maps were thus

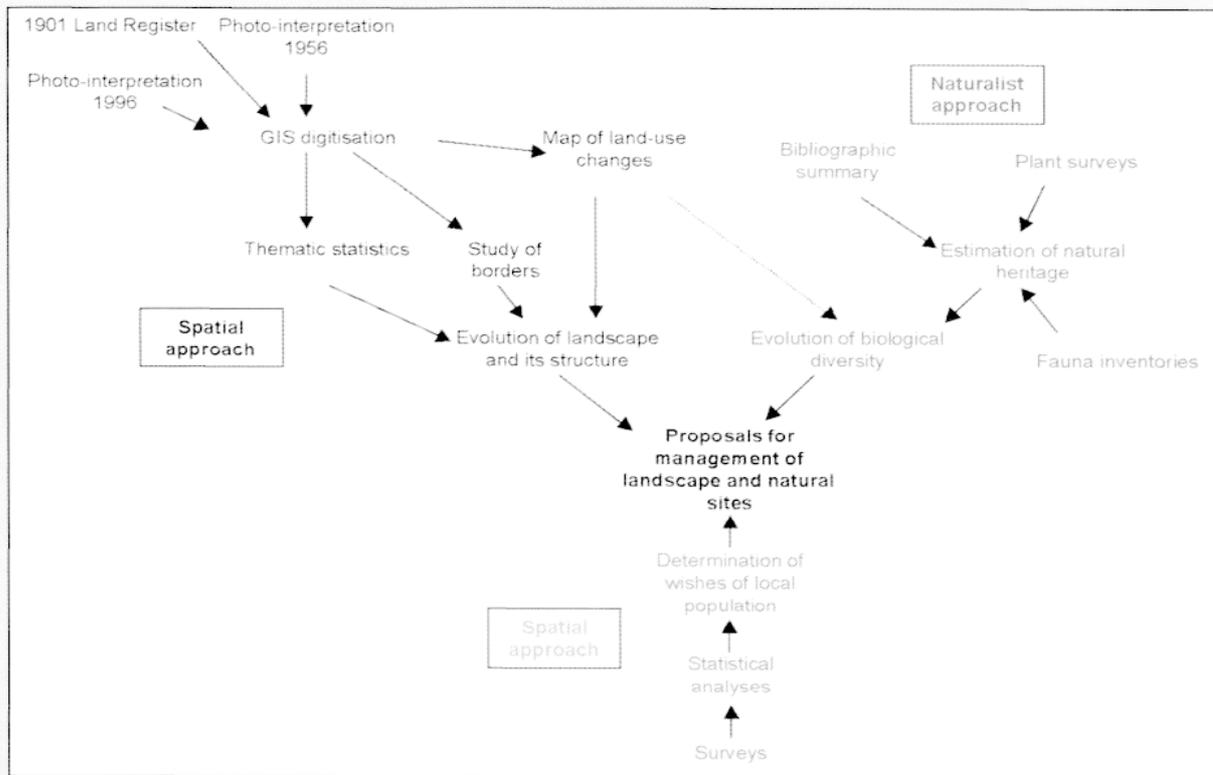


Diagram 1. General methodology.

prepared and then digitized, on the basis of either the land register (1901), or aerial photographs (1956 and 1996). This approach enabled changes in the structure of the Hermillon landscape to be determined.

NATURALIST APPROACH

This approach was used first to establish an assessment of the floristic and faunistic biological richness and, second, to specify the impact of re-colonisation by woody plants on this biological richness. Two different strategies were adopted for the flora and fauna, based on a field approach, the literature and surveys.

The richness of flora was studied by means of floristic surveys. The aim of this approach was above all to estimate the overall richness of the plant community in the study area and its evolution as the land became abandoned. For this reason, plant sampling was conducted according to (1) plant physiognomy and (2) plot history, thanks to the maps of 1901 and 1956. In addition, to estimate the risks of the disappearance of certain plant species following the disappearance of certain physiognomic units (the units shown on the land-use map), we also examined original species, that is those present only in a given physiognomic unit (Vanpeene-Bruhier, 1998). Finally, we also identified protected species and, more subjectively, the rare, beautiful and even emblematic species of the region (such as the tulip of Montandré).

These floristic surveys provided information on:

- original average specific richness according to current physiognomic type and land-use history;
- the location of emblematic species and species with heritage value.

For wild fauna, an assessment was conducted by means of a bibliographic search and surveys among the users of the area. In fact, it is not realistic to set up field protocols to study fauna given that animal behaviour calls for sampling methods that are peculiar to each species.

SOCIAL APPROACH

Seventeen users of the area, corresponding to eleven socio-professional categories¹ were contacted for interviews using a face-to face semi-directive approach (Huntington, 1998). The mayor of Hermillon wanted young people and new arrivals² to the area to be well represented in the sample. The questionnaire (Table 1) was divided into three themes (landscape change, diversity of the natural environment, environmental quality). Some questions were accompanied by photographs of physiognomical units (theme 3, questions b, c, and d).

The aim of this approach was to:

- identify the concerns of users of the area in terms of what they thought of it as a place to live and in terms of the landscape;
- to obtain information on which to base land management decisions that could reconcile ecological concerns and the wishes of local inhabitants.

Theme 1: Landscape changes

In your opinion, is the landscape of Hermillon changing?

If yes, what type of changes have you noticed?

Can you identify where these changes are taking place?

Theme 2: Richness of natural environment

What animal species should be preserved in the Hermillon area?

What plant species should be preserved in the Hermillon area?

Can you locate them ?

In your opinion, are the number and diversity of species increasing or decreasing?

1 • Planners, hunters, young people, farmers, businessmen, elected representatives, new inhabitants, naturalists, photographers, forest rangers, historians.

2 • Neo-rural populations are much more inclined to express their point of view than indigenous populations (Trié *et al.*, 1996).

Theme 3: Environmental quality

In your opinion, what characterises the Hermillon landscape?

Classification in order of preference of 7 landscape types

Classification of two units related to the forest (dense forest and forest with clearings)

Classification of three different types of field and forest borders (straight, indented, progressively indented)

Do you see any problem with the advance of the forest?

Do you see any problem with the retreat of open spaces?

Do you see any problem with the disappearance of the landscape of hedgerow networks (bocage)?

Do you think that the landscape should be preserved?

Among the transformations observed in the landscape in the Hermillon area, which seem to you to be negative, and which positive?

What are the priority actions to be taken to ensure a beautiful landscape, rich in species?

Do you participate in, or would you like to participate in, an activity related to nature in the Hermillon area?

Table 1. Survey questionnaire.

Results

SPATIAL APPROACH: A LANDSCAPE UNDERGOING CHANGE AND BECOMING MORE WOODED

A simple observation of the land-use maps shown in Figure 2³ already reveals that the study area contains former cultivated areas that have become wasteland and that are being re-colonised by woody vegetation.

More precisely, analysis of the changes in surface areas (Table 2) shows that every type of milieu is shrinking, with the exception of forests and urban zones. Thus, forested areas in 1996 occupied almost half the study area, compared with a quarter in 1956, and 15 % a century ago. This increase in the forested area, which has been particularly marked over the last half century, is generally focused on already existing forest core areas (Table 3). In places, it would appear that the forest has advanced as much as 100 m over a 20-year period. In addition, the agro-pastoral decline also seems to have affected the extensive pasturelands, with small areas colonised here and there by woody plants. The marked increase in the number of colonised patches of pastures can be seen on the maps, particularly between 1901 and 1956 (Table 2). Very few forests disappear. Those that do are essentially cleared to make way for roads and urban areas. These kinds of developments, with their marked visual impact, have

3 • The map of 1901, made from the First French Survey (« Premier Cadastre Français »), did not show any distinction between crops or hay meadow with localised re-colonisation and pastureland or heath with localised re-colonisation. These areas were nevertheless in the minority in 1901. In addition, the vineyards that were present in 1901 had already disappeared in 1956.

seen their surface area increase eight-fold over the past century: construction of new infrastructures (namely the Maurienne autoroute) and expansion of the built-up area.

	1901	1956	1996
Crops, hay meadows	77	57	28
Pastures or heath	98	38	28
Crops or colonised hay meadows	-	12	5
Pastures or colonised heath	9	12	5
Hedgerow networks	-	29	8
Dense forest	35	47	114
Anthropised landscape	2	7	18

Table 2. Changes in surface area (ha).

	Number of patches			Changes in structure
	1901	1956	1996	
Crops, hay meadows	25	27	24	Regression around a core area
Pastures or heath	29	37	58	Fragmentation of areas
Crops or colonised hay meadows	-	51	14	Concentration of areas
Pastures or colonised heath	12	30	79	Fragmentation of areas
Hedgerow networks	-	28	29	Regression around a core area
Dense forest	51	84	73	Increase around a core area
Anthropised landscape	5	9	8	Increase around a core area

Table 3. Changes in landscape structure.

NATURALIST APPROACH: A BIOLOGICAL LEGACY UNDERGOING CHANGE

Flora

In this article, we present a summary of the results according to the richness and « quality » (in terms of heritage and originality) of species.

Table 4 shows that colonised hay meadows and colonised pasturelands play an essential role in the floristic diversity of the site, not only in terms of overall richness, but also heritage value and the originality of the species present⁴.

4 • The values obtained for species richness, the number of heritage species and original species in the colonised hay meadows and colonised pasturelands always differed significantly from and were greater than the values of other stages (Mann & Whitney non-parametric test; $p < 0.05$).

In addition, thanks to the historical record of land-use for the sampled plots (each survey is geo-referenced and can therefore be localised on the map of 1956), it may be noted that, taking all units together, the stable milieux between 1956 and 1996 tend to contain more original species⁵. Furthermore, established forest areas (already present in 1956) are richer than recent forest areas.

Finally, these surveys made it possible to spatially locate certain species of heritage value (Figure 3).

	Average number of species per survey	Average number of heritage or emblematic species per survey	Average number of original species per survey
Hay meadows	41.7	1.0	2.6
Colonised hay meadows	61.7	3.9	6.8
Pastures	51.7	1.0	2.8
Colonised pastures	64.3	5.8	6.6
Forests	46.7	2.5	2.5

Table 4. Richness and originality of floristic heritage.

Wild Fauna

The results in Table 5 show, quite logically, an increase in the animal populations that live in forested areas (deer, roe-deer, boar) at the expense of those living in more open milieux (partridge, hare, rabbit). The appearance of an exclusively woodland landscape leads to two distinct risks:

- disappearance of numerous species (ibex, chamois, grouse, etc.) that require a habitat with open spaces (facilitating search for food, providing places for rest and reproduction);
- rapid multiplication of woodland animal species. Some inhabitants surveyed indicated that the increase in animal numbers was already causing concern as the animals were becoming a nuisance: boars, badgers, stoats, foxes.

5 • The results of these more detailed analyses, however, were not sufficiently numerous to be used in a statistical test. Only trends are therefore presented here.

Species	Change in population	Landscape units frequented
Boar	Increasing	Every type. Avoids areas with not enough cover and high altitudes
Ibex		Mixed terrain, forest with clearing, borders
Roe-deer	Increasing	Deciduous forests with clearings
Chamois		Pastures, forests, rocks
Deer	Increasing	Forest borders
Fox		Every type of milieu
Wild rabbit	Decreasing	Open areas, with localised colonisation, or forest borders
Hare	Decreasing	Open areas
Badger		Deciduous forests with clearings
Squirrel		Forests
Grouse	Decreasing	Forests with clearings
Ferret		Forests, hedgerow networks
Stoat		Avoids dense forests
Marmot		Open areas, pastures
Capercaillie	Decreasing	Upper margins of forest
Partridge	Decreasing	Fallow land, fields
Buzard		Cropped zones
Pheasant	Disappeared	Fields, forests, scrub
Viper		Open areas
Eagle	Disappeared	Rocks, forests, open areas

Table 5. Results of fauna inventory.

SOCIAL APPROACH: WHAT TYPE OF LANDSCAPE FOR WHAT TYPE OF HERITAGE?

Perception of a changing landscape

Over 80 % of those surveyed (14 out of 17) felt that the landscape was changing, with ten among them identifying changes in vegetation, and four referring to industrialisation and urbanisation. These changes were mainly perceived in the most frequented areas (around the village, along the roads, from viewpoints).

In addition, the majority of people interviewed were concerned by the encroachment of the forest and the shrinking of open spaces, and regretted the disappearance of the hedgerow network landscape (bocage). There was a unanimous « yes » for maintaining the

landscape, with priority being given to the fight against letting former farmland go to waste. In general, people felt attached to nature in their local area, and regarded it as an asset in terms of quality of life and even from an economic point of view. One company director said he considered the landscape and environmental quality to be important factors in the decision to set up business in an area.

This survey underlines the fact that the residents of Hermillon are concerned by the changes affecting their landscape, even if few among them had already thought about these changes, perceiving what is happening only through a few particular cases that they are familiar with. One person might notice the arrival of fallow land next to his house, another might realise that certain fields are no longer maintained, but few people perceive the landscape changes over the community as a whole.

A little known biological heritage

Animal species, particularly large game, were better known than plant species. Only two people interviewed were able to correctly name a few interesting plant species. The Montandré tulip, the commune's emblem, was the only plant frequently mentioned. Several people interviewed felt that there had been a decline in the wildlife of the more open habitat, and missed seeing animals that were part of their commune's heritage, such as the eagle and the partridge. The increase in « harmful » animals (especially the wild boar) and large game was clearly perceived, and a majority of interviewees complained about this wildlife « invading » the village: nuisance, feeling of insecurity, damage to gardens, crops spoiled, not to mention the risk of road accidents.

Reconstructing the landscape

Most people interviewed therefore felt that the landscape was undergoing a marked change (invasion of shrubland, then forest) and considered it harmful to their living environment and natural heritage. What type of landscape do the people of Hermillon therefore want?

The results of our surveys are clear: people said they wanted a heterogeneous – but nevertheless organised – landscape. Thus, photographs showing landscapes with a mixture of milieux (hedgerow networks, open spaces with localised re-colonisation) were the most appreciated. Respondents preferred forests with a mixture of trees, and complex borders were particularly valued. While there is a trend toward the landscape being standardised by forest areas, with open spaces maintained around the hamlets, the local population of Hermillon would like a landscape that is « clean » (no fallow land), varied and heterogeneous. The best example of the difference between the reality of the changing landscape and the desires of the local population is the hedgerow network landscape (bocage). This is both the preferred type of landscape of the local residents and the type that has practically disappeared.

Finally, one of the major problems raised during the interviews concerned abandoned farmland. Everyone considered it to be a waste of space (since « it serves no purpose, and produces nothing ») and a hostile environment (impenetrable thorns, dense thickets).

Towards land management which preserves the biological heritage and environmental quality

Our analysis clearly identifies the risks associated with landscape uniformisation by the spread of forestland: disappearance of remarkable habitats, general decrease in biodiversity, proliferation of animals that cause harm, degradation of living environment.

The commune's objective is now to identify and optimise land management measures. But how and where should such measures be implemented? The results of this study provide some useful insights for answering these questions.

STOPPING OR LIMITING ENCROACHMENT BY WOODLAND

In a context of general encroachment by the forest, priority must be given maintaining open spaces. For this reason, the municipality of Hermillon would like to set up an Association Foncière Pastorale⁶ (Pastoral Land Association). This measure would solve the problems caused by fragmented plots and would enable a farmer to set up in the commune who would be responsible for both agricultural production and managing the land in the upper part of the study area. Tasks would include clearing, dealing with different grazing problems depending on the sector, mowing, tree and hedge maintenance, and maintaining a pleasant living environment.

MAINTAINING A DIVERSITY OF MILIEUX AND HABITATS

We have already stressed the risk of landscapes becoming more homogeneous and in particular the gradual disappearance of certain physiognomic units. Local heterogeneity (horizontal and vertical) in landscapes maintains plant diversity and enables certain animal species to optimise food resources, and reproduction and protection areas. In addition, they contribute to a more pleasant image in the minds of walkers, hikers, and naturalists.

For certain animals, it is essential that heterogeneity be taken into account at the scale of the commune. For example, to prevent invasion by hoofed animals, measures should be envisaged to open up parts of the densely forested areas and to maintain connections with the main forested zones (see next paragraph) in order to reduce the pressure of all these forest animals on agricultural land.

PLANNING A DIVERSIFIED AND CONNECTED FOREST

Most people tended to have a rather detached view of the forest. Not for what it is in itself, unlike abandoned land, but because they saw it as responsible for closing in the landscape. Although this expansion of the forest area does indeed reduce habitat diversity and lead to greater nuisance from animals and a reduction in the quality of the environment, the forest

6 • An AFP is a group of owners who rent their pastoral land to stock breeders so as to make use of the land and to keep it from becoming abandoned.

is nevertheless indispensable for the Hermillon landscape, provided certain features are preserved or acquired. The required conditions are as follows:

- preserve an extensive forest area in a single tract in order to sustain forest animal populations and also to serve as a reservoir of species for the other forest units;
- maintain a certain number of separate woodland areas, connected to the forest « reservoir » by hedgerow networks (bocage);
- envisage openings here and there and continuums in physiognomic transition areas that are essential for preserving certain habitats;
- suggest a method of forest management which favours vertical heterogeneity in forest stands, indispensable for maintaining a diversity of habitats and food resources.

RESPECTING THE HISTORY OF HERMILLON AND ITS LANDSCAPE

Centuries of human activity and accumulated knowledge prior to the decline of agriculture fashioned a landscape in which each element had a reason. It is clear that the oldest forest must be maintained. The floristic surveys showed that it is these forests, and not the wooded areas that have appeared spontaneously in more recent years, that are the richest in flora. It also appears of utmost importance to maintain – and even reintroduce – hedgerow network landscapes (bocages) because of their ecological utility: contribution to heterogeneity of landscapes, role as a habitat or to facilitate circulation of certain animal or plant species, connections between forest units.

Last, it would be perfectly feasible to introduce an overall land management project to protect the area's biological resources in general, with particular emphasis on the preservation of certain emblematic species. The Montandré tulip would thus be a species to take into consideration, in that its image remains closely linked to the history and the very soul of Hermillon. This species can be preserved only if the large open spaces in the area are maintained.

DETERMINING THE FOCUS OF ACTIONS IN THE HERMILLON DISTRICT

Drawing up a broad outline of actions to be taken, as we have done here, does not provide Hermillon with practical answers to its problems. The recommended actions must be related to specific locations in the area. The municipality will then not only have a document that it can use directly, but it will also settle the case of a few actions that might be problematic. For example, the issue of abandoned farmland is the only case where there is an obvious contradiction between ecological interests and the wishes of people using the local space. It might be suggested that certain abandoned areas be maintained to ensure a diversity of environments and habitats, but that these areas should be confined to the least accessible and least visible parts of the commune.

The localisation of suggested actions (Figure 4) takes into account the following parameters:

- the history of the landscape, based on the 1901 land register;
- the evolution of the landscape between 1956 and 1996;
- general information on types of flora and fauna and changes observed;
- precise locations of certain emblematic or protected species (Figure 3).

For example, we can suggest which long-established wooded areas should be preserved (La Fontanette slopes), which former cultivated areas should be maintained (in Echaillon), or cleared (around Hermillon, de Montandré), and suggest places where hedgerow network landscapes should be preserved or developed (in the vicinity of Champessuit or Le Soir).

Conclusion

In line with its objectives, this study has provided an analysis of the problems facing Hermillon and has also sensitized the local population to the issues of land management and how they can be settled. Our contribution has been to provide information, heighten awareness of some general concepts (heterogeneity, connectivity, etc.), and suggest a range of clear actions that might be taken, classified according to their utility and impact. The implementation strategies themselves are the responsibility of the municipality of Hermillon or the local or regional authorities concerned, and will depend on ecological, environmental, social and budgetary considerations.

The results of the present study are specific to the biogeographical, historical, social, cultural and economic context of Hermillon, and therefore cannot be used to make generalisations. For example, while abandoned farmland is unanimously perceived in Hermillon as vegetation with no purpose and even as having a negative impact, a similar study in the Southern Alps showed that the opposite was generally true in the study area concerned (Trié *et al.*, 1996).

The three approaches (evolution of landscape, biological richness, surveys) may seem superficial when taken separately, particularly with respect to sampling. While this study may not be considered research as such, it is nevertheless based on a certain amount of prior knowledge and on scientific concepts (landscape ecology) and was designed to minimise – though not eliminate – data collection and its associated costs in terms of both time and resources. We thus believe that the method described here is a realistic compromise for conducting an ecological analysis in a small mountain district that has seen a rapid transformation of its landscapes.

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