Chapter 7

Landscape and vegetal diversity of forest islets

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CONTENTS

INTRODUCTION : WHICH DIVERSITY TO OBSERVE?

The European forest cover is particularly especially fragmented in the rural areas in which any form of timbering takes ineluctably appearance a true zone of refuge for the biodiversity in these strongly artificialized territories (cf chapter 8). This biodiversity is generally declined according to three scales : ecological diversity (or diversity of the ecosystems), specific diversity (or diversity between species) and genetic diversity (or diversity within d'une even species, intraspecific diversity), (Academie des Sciences, 1995 ; Blondel, 1995).
The ecologist François Ramade, in the *Dictionaire encyclopédique de l'écologie et des sciences de l'environnement*, written : "the term of biodiversity (biological diversity) quite simply indicates the variety of the alive species which populate the biosphere. Taken with the simplest direction, the biodiversity measures by the total number of species alive (plants, animals, mushrooms, micro-organisms), which contains terrestrial whole and watery ecosystems, currently meeting on planet : scientists call total richness" (Ramade, 1993).
It thus seems necessary to utilize scale and extent of biogeographic territory considered in the analysis of the biodiversity, which makes it possible to better evaluate the quality and the

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quantity of the alive beings on a territory which appears on all the levels organization of alive, integrating the multiplicity and abundance species, the variety of their organization in ecosystems different and complexity from the relations between these ecosystems (Ramade, 1993 ; Blandin, 1996 ; Barbault, 1997). In addition, one should not especially omit in this analysis the role of human activity which affects this biodiversity considerably. Indeed, observed with scale of the territory and the landscape, this one corresponds to a richness exploited by the human societies like the animal and vegetable communities and constitutes an essential component of the geosystem and landscape (Rougerie, Beroutchachvili, 1991).
In this research, the analysise of the biodiversity of afforestations of the rural areas is based on a multi-scale approach resting jointly on remote sensing data and ground data (Galochet *et al*., 2002). This step, allowing to approach the diversity of the forest landscape of the rural areas by a system of ground investigation, generates dialectical scales necessary for a better comprehension of the small forest objects dispersed like the forest islets in countryside.
To seize the vegetable biodiversity of the forest islets, it is advisable first to count whole areas wooded on the studied territories, then to isolate them from the remainder of the landscape in order to release their spatial distribution and their size. They are essential preliminary stages allowing an external approach of the forest islets. Then, a ground investigation offers an internal approach of the forest islets to collect the information. It's only starting from this multi-scale approach, that the analysis of the factors of the forest islets biodiversity could be explained.

1. AN APPROACH MULTI-SCALE TO OBSERVE VEGETAL AND LANDSCAPE DIVERSITY

To understand landscape and vegetal diversity of forest islets of european countryside, claims an encased step, of external then of internal, associating satellite image and ground data (Godard, 1991). This stacked approach, merging ground investigation and remote sensing imagery. The methodology starts from spatial sampling, allowing the analyst to study the islet both from above and from the inside, describing both landscape diversity and structures diversity. We are then describing forest islets as society-related, highly humanized areas, then as relicts of confrontation between natural constraints and human action. Landscape and forest diversity of islets is as well depending on natural conditions and human activities lasting from ages.
The change from external to internal of forest islets, who controls all the scalar levels (Girard *et al*., 1996), is made by means of satellite image to observe above of islets, and then by use aerian photography to help the statements of ground and to penetrate the inside of the forest islets (Galochet *et al*., 2002). There are true refuges and play the role of conservatory of natural wealth in huge agrosystems. However, their main interest in not only ecological matters, as they are as well production, protection and relaxation areas. But how to seize their diversity starting from the data images and of the data of ground ? Is there a bond between their size and their vegetable diversity ? How to locate them and insulate them starting from the data images ?

An external approach of the forest islets by the data images

Taking into account the small surface and of space dispersion of the forest islets, it is necessary to use pertinent geographical tools, like satellite image, to seize the greatest number of wood, their space distribution, then to circumscribe them and determine their space orientation in the landscape of the countryside. For that, we chose to work with an satellite image offering a sufficiently large territorial level to seize organization of space wooded and

to observe its influence space (Bonn *et al*., 1993 ; Bonn, 1996 ; Girard *et al*., 1975 and 1989). This document makes it possible to carry out a step encased to three analysis levels.

- First, to locate forest islets in a fragmented forest cover within rural areas dominating.
- Then, into negative, it is possible to highlight the interface between two systems ; the agrosystem and the sylvosystem.
- Lastly, the third level makes it possible to seize the nature of the vegetable settlements, the structures and the vegetable formations which compose the largest forest islets.

Knowing that the space resolution a multispectral Spot pixel covers a surface of 400 m^2 (less one half-hectare), it seems quite difficult to be able to seize the small forest islets because of their low dimensions and of their dispersion in the countryside. It's why, it is necessary to select the satellite image according to constraints' of space perception and resolution, then according to phenology and the farming calendar. Some anterior studies showed that the satellite imagery of average resolution (Spot) constitutes the best choice, among l'ensemble sensors proposed, for the location of the forest islets taking into account its capacity to discriminate them finely, with the proviso of working on an image of autumn beginning; period when the grounds either are discovered or plowed, or covered by a not very covering herbaceous vegetation (Galochet, 1999 and 2001 ; Hotyat *et al*., 1997 and 1999 ; Liège, 1997). Thus radiometric contrast is sufficient to isolate the woody vegetation from the forest islets. The choice of satellite image thus constitutes an essential precondition to seize the forest islets, then to establish a space sampling plan guiding the analysis ground data.

Figure 1. Distribution of the transects and extraction of forest islets o the satellite image SPOT.
(M. Galochet)

The satellite image, supported topographic chart to the 1/50 000, is used as background document to count the forest islets, to isolate them from the remainder of the radiometric landscape by a not directed classification, and to confront with exactitude of this document with the aerial photography, then to extract them by the mask method in order to release their spatial distribution, their form and their size.
This masked file obtained, makes it possible to seek principal orientation of the forest islets with an aim of determining the position of the transects for sampling then the ground data along these observation lines (**figure 1**). The meeting of the battery of transects, equidistant of 500 meters (multiple of the topographic map to the 1/50 000), with the forest islets makes it possible to sample them according to their size (typology in three classes : small, medium, large islets). This preliminary phase with investigation of ground thus offers a certain representativeness of whole space wooded of the studied territory, and guides the internal approach of the forest islets.

An internal approach of the forest islets by the ground observation

After having determined the spatial sampling, the second series of stages of the stacked approach allows to observe the forest islets at the local scale and to collect the ground data. of The ground observation, realized length a transect – being used unity as collection of information – who crosses a forest islets right through, counts the stratification and the floristic composition (dominant gasolines for each layer of vegetation : herbaceous, shrubby, arborescent).

The ground observation, which also consists in describing the forest structures of the forest islets, is supplemented by the information contained on aerial photography. These forest structures reveal individual decisions or the public managements retained by the foresters in the course of time, like a stacking of last multiples (Husson, Degron, 1999). The forest islets accumulate the memory of the cuts and forestry practices, detectable in the forest structures, which according to the compartmental one, thus offering a strongly diversified forest cover (Hotyat, Galochet, 2001).

Thereafter, the ground data are seized in a file of the dominant species by transect and layer, in terms of presence/absence of information. To treat the ground data, a simple classification by ascending order reveals the dominant gasolines all confused layers, by layers of vegetation, wood size, transect… This study multiparameters, realized with elementary statistical treatments, also makes it possible to establish a bond between the size of wood and their vegetable wealth of classifying the segments of transects per length. After homogeneity and controls tests, we can inject the results of the preceding stages into the whole of satellite image. Thus, this step makes it possible to generalize information with the other forest islets not retained in spatial sampling and to return tothe regional scale.

This stacked approach, applied to the analysis of the forest islets in countryside, rests on data images of nature different offering from additional geographical information. But the exploitation of these data images generates also new information, like space organization, the form, the size, the distance between the forest islets, which enrich perception by the territory and that of the object studied. The virtues of this stacked approach allow to release the parameters identifying the forest islets starting from the data satellites images, then to analysis their contents, in particular their forest structures with aerial photography to support the ground investigation (Hotyat, 1990). This stacked approach offers the possibility to observe

landscape and vegetable diversity, and to understand the ecological and anthropic factors explanatory (Ryszkowski *et al*., 1996 and 1997).

2. THE FACTORS OF THE BIODIVERSITY OF THE FOREST ISLETS

The diversity of the forest islets depends on several variable factors according to scales' of observation : at the regional scale, the insulation and the fragmented forest cover ; at the wood scale, the exploitation of the forest resource.

At the regional scale, a diversity related to insulation of forest islets

The forest islets contribute in landscape diversity by insulation of woods in the geographical context of the countryside. More'over, they dependent on the split up regional forest cover, but also on the remoteness the ones of the others (Levenson, 1981). So the insulation of the forest islets corresponds to the principal factor of the diversity of afforestations, then an hypothesis can be posed : is this a gradient of parcelling out of the woodland cover (size) maintains a greater diversity landscape ? On the analysis ground, the forest islets are distributed in regional space in two different ways, either completely isolated from any other wooded formation, or grouped in archipelagoes. The question of the insulation effect of a forest islet about its richness thus arises on two levels :

- Does exist the effect in the interior of the archipelagoes distant of a continent-source more important ?
- Does exist also this effect for islets completely insulated ? Is vegetable diversity all the less rich they are more isolated ?

In her thesis of ecology, M. Linglart (2000) distinguishes also two spaces of organization types for forest islets in countryside while taking as limit of insulation effect of the threshold of 500 meters (**table 1**). Thus, the first type corresponds to wood completely isolated located at more from 500 m of any other wooded formation (last column of table 1), the second with wood grouped in distant archipelagoes between them more than 500 m (the first three columns of table 1).

Table 1. Insulation and specific richness (RS) by insulation class. (after Linglart, 2000)

Insulation (m)	50	100	200-500	> 500
RS average (%)	99,5	99,7	98,2	64,7
RS standard deviation	40,2	54,3	45,3	14,4
Surface average (ha)	3,7	6,3	3,3	1,2

This table shows that the insulation seems to have an influence on the specific richness, since wood located at more than 500 meters are less rich than wood belong to archipelagoes (class < 500 m). Their average richness is 64,7 % counters approximately 100 % (respectively 99,5 ; 99,7 ; 98,2). However, let us specify that eight wood the most insulated have on average a surface much smaller (1,2 ha) that those included in archipelagoes. The statistical results of the table show "in tne interior of the archipelagoes the average richness of a forest islet independent of its insulation degree [but wood] there more isolated (> 500 m) are overall less rich" (Linglart, 2000).

If in this example, the conjugation of the insulation and the size, explains the low specific richness of forest islets, on the other hand our ground observations, by the transects method,

show a clear relation between the size of wood and their vegetable richness. Indeed, the number of dominant species listed in the forest islets of Great Poland reveals that wood largest are diversified, in dominant species term, according to our samples selected (**figure 2**).

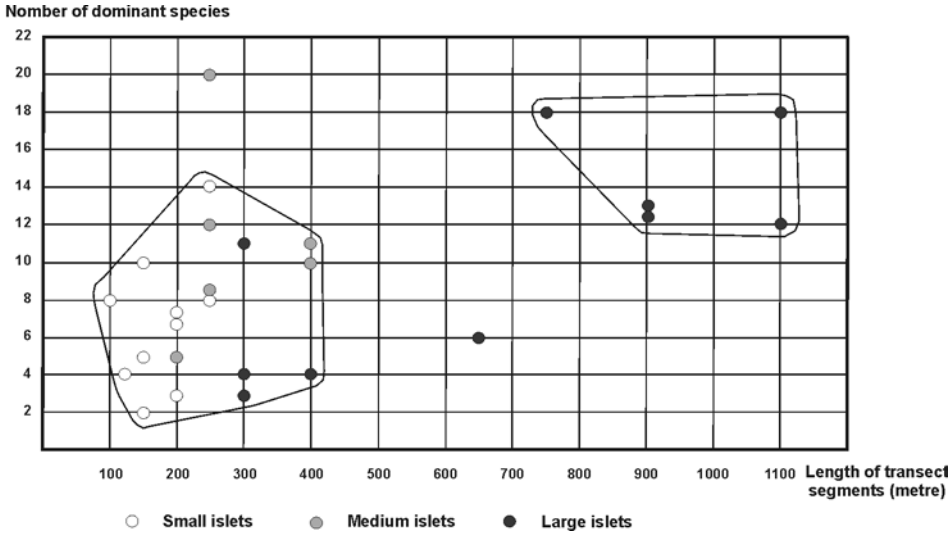


Figure 2. Relation between vegetable richness, size of the wood of Great Poland and length of the transects. (M. Galochet)

In this figure two sets are distinguished : the first, composed of large islets, concentrates more dominant species, the second mixes the small and the medium islets. This calls two remarks.

- The dominant species most were listed in largest islets and with longest transects, which make it possible to cross many parcels of land. Inversely, shortest transects are not allowed to count that little dominant species, and are not crossed that small islets. There is thus a strong correlation between the size of wood and the length of the transects, but also between the size of wood and the vegetable richness, largest islets being diversified more.
- An aggregation between the small and the medium islet drink occurs. This reveals a too fine typology for the size of islets. Two classes would have seems it is enough to make this study. Let us recall that the delimitation of the three islets classes respects the definitions of the IFN (Institut Forestier National) being distinguished the thickets from 5 to 50 ares, the small woods of 50 ares to 4 ha and the forests beyond 4 ha. These three categories correspond to small, medium and large islets our typology.

If large wood concentrate more dominant species, they are very few compared to the class of small (9 large against 20 small). This classification, simple, founded on cutting out of a variable by the intermediate of the parameters of its distribution (here size), reveals an important vegetable diversity for largest islets. However, the vegetable diversity of the forest islets can to explain only by their size, others whole factors related to the morphology of islet but also the parcelling out and an insulation degree would probably make it possible to better understand diversity with an multifactors analysis.

Even if however the insulation seems to be an important factor in the explication of the vegetable richness of the forest islets, one should not exclude the many interventions and human activities which are likely to influence, in a more or less direct way, their vegetable diversity. Indeed, the practices of the forest owners support the heterogeneity structural of the vegetation combined with the role of compartmental the multitaille at the wood scale.

At the wood scale, a diversity related to the exploitation of the forest resource

The exploitation of the forest resource is to be regarded as an enrichment factor determining of the vegetable diversity of the forest islets (Corvol, 1987 ; Larrère, Nougarède, 1993). Indeed, the wood cuts transform the natural conditions of the more important in particular by the supply of light on the ground allowing arrival of light species, and thus condition the dynamics of vegetable reconquest which succeeds to him. The intra-forest wood cuts dissect the vegetable cover in many units of variable size whose the extend and forms it cuts are generally related to compartmental land which involves a multitude of development stages shifted in the time to parcel in parcel, since the last to wood cuts ripe groves, and offer a strongly diversified forest cover. The forest islets are thus transformed into a true mosaic of parcels born of the various owners practices.

In addition, should not be forgotten that the current vegetable diversity of the forest islets depends also on the forestry modes of management passed, than to do integrate in an durable management approach anxious to respect ecological requirements built on a logic of long time and needs economic (Langevin, 1997). If the taking into account of space dimensions is necessary in biogeographic analysis of the biodiversity, it is also necessary to associate a reference to temporal dimensions it (Agger, 1996), like are pointed out P. Arnould, M. Hotyat and L Simon, at the conference "History and forest resources" of the IUFRO (International Union of Forestry Research Organizations) with Italian Academy of forest sciences of Florence in 1998, by proposing the concept of "geochronodiversity" (Arnould *et al*., 2000). Based on the space and the time, our stacked approach inscribes in this logic, by integrating data of various nature (aerial photographies, satellite images, land registers, ground observations…) in a geographical information System to harmonize the various approaches of the landscape and specific biodiversity.

3. THE STRATIFICATION, A MARKER OF BIODIVERSITY

A stratification related to the species represented

A certain number of variables were collected on portions of transects, the segments, at the time of the ground investigation. Rather than to review all the possible combinations of variables, we made the choice constitute a typology of the relevant variables on the groups of segments which combine by statistical "affinities". That made it possible to release the combinations interesting "to dig". The presentation of typology is the purpose of this chapter. A vision of the landscape biodiversity out of spring. The original data are varied. There is in first the active continuous data which constituted the heart of treatments. It concern the importance of the strata according to the species represented. The headings and characteristic of the strata are as follows :

[0 cm ; 50 cm[=> Strate 1 (Str1) ;
[50 cm ; 2 m[=> Strate 2 (Str2) ;
[2 m ; 7 m[=> Strate 3 (Str3) ;
[7 m ; 15 m[=> Strate 4 (Str4) ;
[15 m ; 25 m[=> Strate 5 (Str5) ;
>= 25m => Strate 6 (Str6).

The total species number present by segment (nbespeces) was integrated like illustrative continuous variable, just like the sum of the species present by strata (sstrat). The belonging of a segment with grove (thicket : surface ranging between 5 and 50 ares), with an average wood (copse: surface included between 50 ares and 4 ha) or with a large wood (forest: surface upper than 4 ha, IFN, 1985, pp. 19-20) concerns the illustrative nominal variables, like the

floristic statements, coded in – presences; absences, which relate to 56 species. The objective was to see whether the vertical stratification is a marker of the landscape biodiversity. The illustrative variables do not interfere in calculations. They position compared to active but do not influence on the treatments. PCA (principal component analyses) then AHC (ascending hierarchical clusterings) were applied to them. The partition in four classes, proposed by software SPAD V.5.5 and retained for this study, comprises an inertia inter classes of 3.2 for a total inertia of 6 (quotient inertia inter/total inertia = 0,53). The four classes respectively count 13, 4, 5 and 4 segments. Of the three partitions suggested by the software, respectively 4, 6 and 8 classes, it's the first which was retained because it does not comprise individual all alone isolated constituting a class with him and each class is described there by at least two variables. Its four classes have profiles, and manpower, definitely different. The first is the least singular (**table 2**), it's nearest to the centre. Moreover, it relates to a greater number of segments. In revenges, the three last classes are relatively more "typical" with distances with the zero point between four and seven. Two kinds of variables are represented on the figures n°3 to 6. It concerne, on the one hand of active continuous variables (Str1 with Str6) and the other hand of the illustrative continuous variables (nbespeces and sstrat).

Table 2. Distances of class in the centre of the cloud.

n° of class	Distances at the origin
1	0.75725
2	5.21822
3	4.20465
4	7.65452

A stratification in four dominant classes

In terms of variables (**figure 3**), the first class it isn't significantly characterized that by under-representations (are not retained, like significant, that the classes whose values test, calculated on T of student, exceed two). It relates to primarily the shrubby strata (Str3 of the 2 and 7 m) and the strata of the very large trees (Str6 of more than 25 m). That means that these two strata are 40 to 50 percent smaller on this class than on the whole of sample. For the other variables, they, significantly, neither on are represented, nor under represented. As regards the individuals (segments), this class concerns to a large extent of the survey segments located in the thickets (7 out of 13), a weaker share in the small woods (4 out of 13) and for an unimportant share the forests (1 out of 13). Let us note however that these illustrative variables (belonging to a wood size), because of the small size of sample, have never significantly qualified one of the classes.

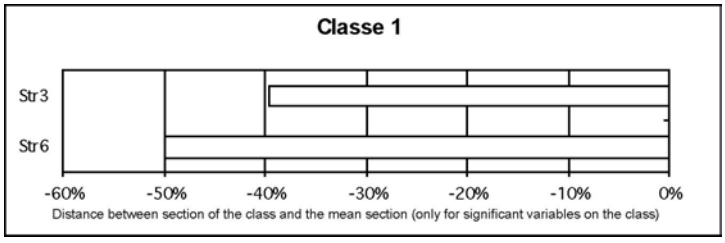
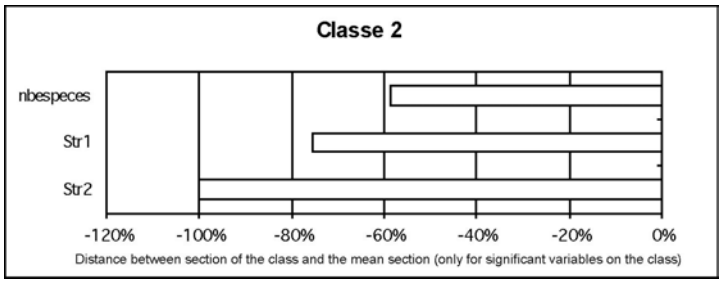


Figure 3. Variables characteristic of the Class n°1.
Are described only the significant variables (of which the value test is higher than 2).

The value of the profile of each variable corresponds to the average in the class minus the general average of this variable the whole divided by the average general of this variable (expressed in p. 100). With a rather strong standardized distance [distance with the barycentre of 5,2 (Table 2)], the second class "is typified relatively more" (**figure 4**). However, she does not know either a overrepresentation. She relates to primarily the species number with segment (nbespeces)et the low and high herbaceous strata (Str1de 0 to 0,5 m and Str2 from 0,5 to 2 m). It's thus a class "poor" in total specific richness and in particular on the two low



strata. This class, very few, relates to only one investigation segment located in the thickets (1 out of 4) and three segments located in the forests (3 out of 4).

Figure 4. Variables characteristic of the Class n°2.
Are described only the significant variables (of which the value test is higher than 2).

With a standardized distance hardly weaker [distance with the barycentre of 4,2 (Table 2)], the third class remains relatively "offset" (**figure 5**). However, this time, they are them overrepresentations which characterize it. With the arborescent strata higher (Str6 of more than 25 m) more twice higher than the general average of sample for this strata (108 p.100), this class is marked by a strong specific variety in high strata. This is found, although to a lesser extent, in shrubby strata (Str3 from 2 to 7 m, 86 p.100) and in low herbaceous strata (Str1 from 0,5 to 2 m, 50 p.100). The individuals of the class n°3 belong for only one fifth to the thickets, two fifths with the small woods and also two fifths with the forests (2 segments out of 5).

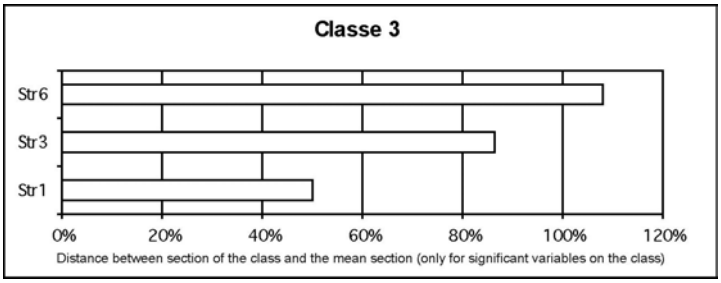


Figure 5. Variables caractéristiques de la Classe n°3.
Are described only the significant variables (of which the value test is higher than 2).

With a stronger standardized distance [distance with the barycentre of 7,7 (Table of the distances in the center of the cloud)], the fourth class is "offset" (**figure 6**). There still, in fact the overrepresentations characterize it. With low and high arborescent strata (Str4 from 7 to 15 m, 212 p.100, Strat5 of 15 m to 25 m, 146 p.100) more twice the higher than the general average of sample for this strata, this class is marked by a strong specific variety in arborescent strata. The high herbaceous strata is also in this case (Str2 from 0,5 to 2 m, 112 p.100). The sum of the species present by segment or strata (nbespeces and sstrat) also confirms it by its overrepresentation. Lastly, this class on is represented for the larch (*L*

decidua) compared to the surveyed average profile of the population. 75 p.100 of the segments of this class have larch (then they are only 15,4 p.100 on the whole of parcels). The individuals of the class n°4 belong for only one quarter to the small woods and three quarters to the forests (3 out of 4).

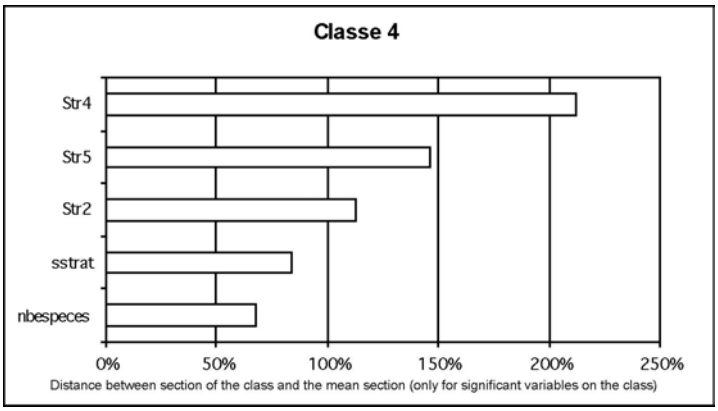


Figure 6. Variables characteristic of the Class n°4.
Are described only the significant variables (of which the value test is higher than 2).

This typology in four classes imperfectly take again cutting into small, medium and large woods. It can be on one hand because of the weakness of sample, the sizes of wood did not leave like variables discriminating typology, but also because this cutting "à la française" does not recut the reality of the landscape diversities inherited Prussian forestry. It would be advisable on one hand to re-study this cutting by modifying some the limits, to introduce again segments to pack sample and test this analysis on a new territory.

- The yellow circles positions the barycentre of each class. They are proportional to the number of segments they represent. Each segment selected (quality of the representation higher than the median of Cos^2) is also represented by a circle proportional to the square of its co-ordinates (Cos^2).
- The vectors indicate orientation and intensity of their representation on this factorial design. They are the old unit axes (of Str1à Str6).
- The share of inertia of each factor is indicated beside this one.

CONCLUSION

Encased biogeographic approach shows a complementarity as well information as scales. The analysis of the territory by the association of the data images (satellite image, map topographic, aerial photography, cadastre…) allows to individualize the forest islets in the landscape and to seize the dominant structures facilitating for example the distinction between the variations of densities and textures in an even parcel. This approach also integrates the combination of processes spontaneous and anthropic by confronting the natural constraints and the human interventions which jointly explain the current diversity of these afforestation.

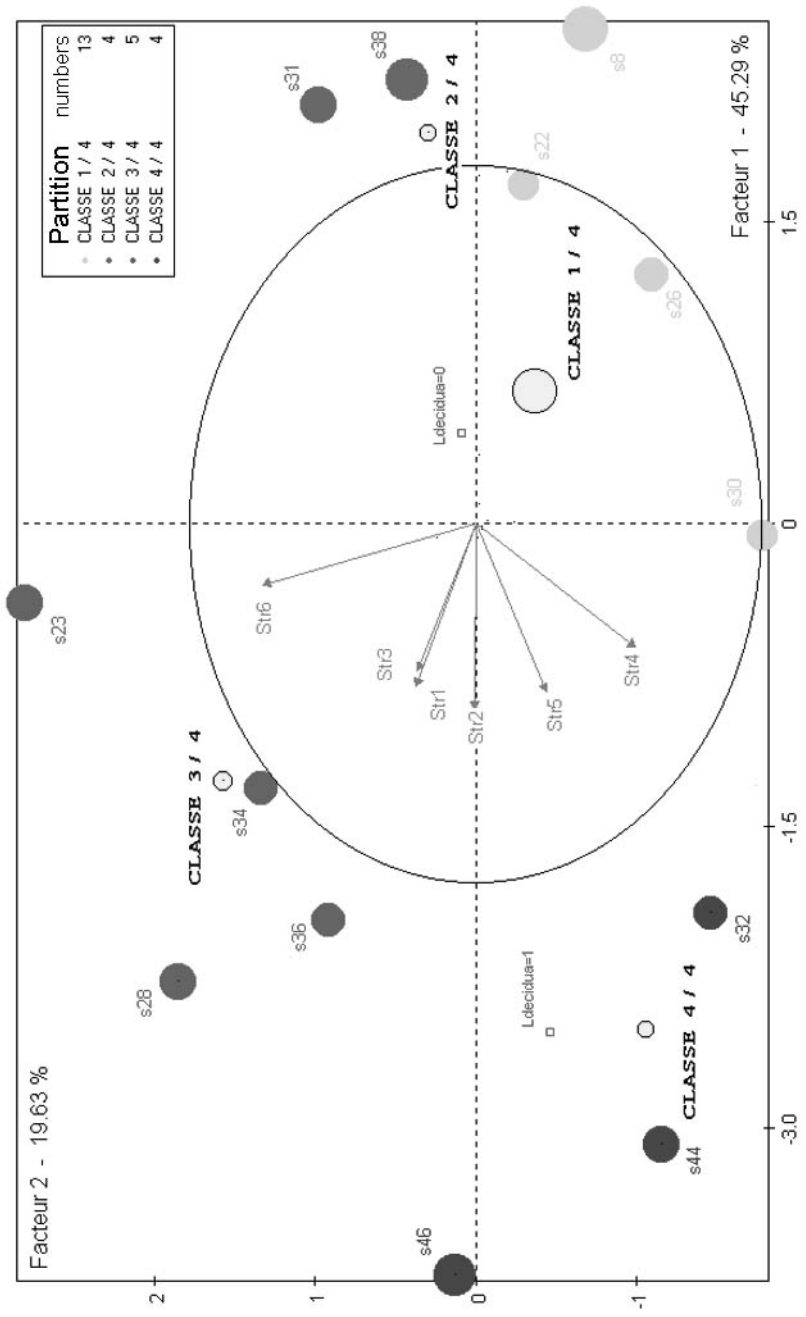


Figure 7. Distribution of the four classes on the first factorial design.

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