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Agricultural and environmental engineering research

Office National des Forêts

Modelling the spatial structure of heterogeneous stands. Example of sessile oak *(Quercus petraea)* – Scots-pine *(Pinus sylvestris))* mixed stands of the Orleans forest in France.

M.A. Ngo Bieng[12]

C. Ginisty[1]

F. Goreaud[2]

[1] Research group « Forest ecosystem » (CEMAGREF Nogent / Vernisson, France).

[2]Laboratory of engineering for complex systems (CEMAGREF Clermont – Ferrand, France).

IUFRO 1. 14. 00 Research group conference. May 14-18, 2006. Rouyn-Noranda, Québec Canada

Natural disturbance - Based silviculture – Managing for complexity

Outline

I. Introduction

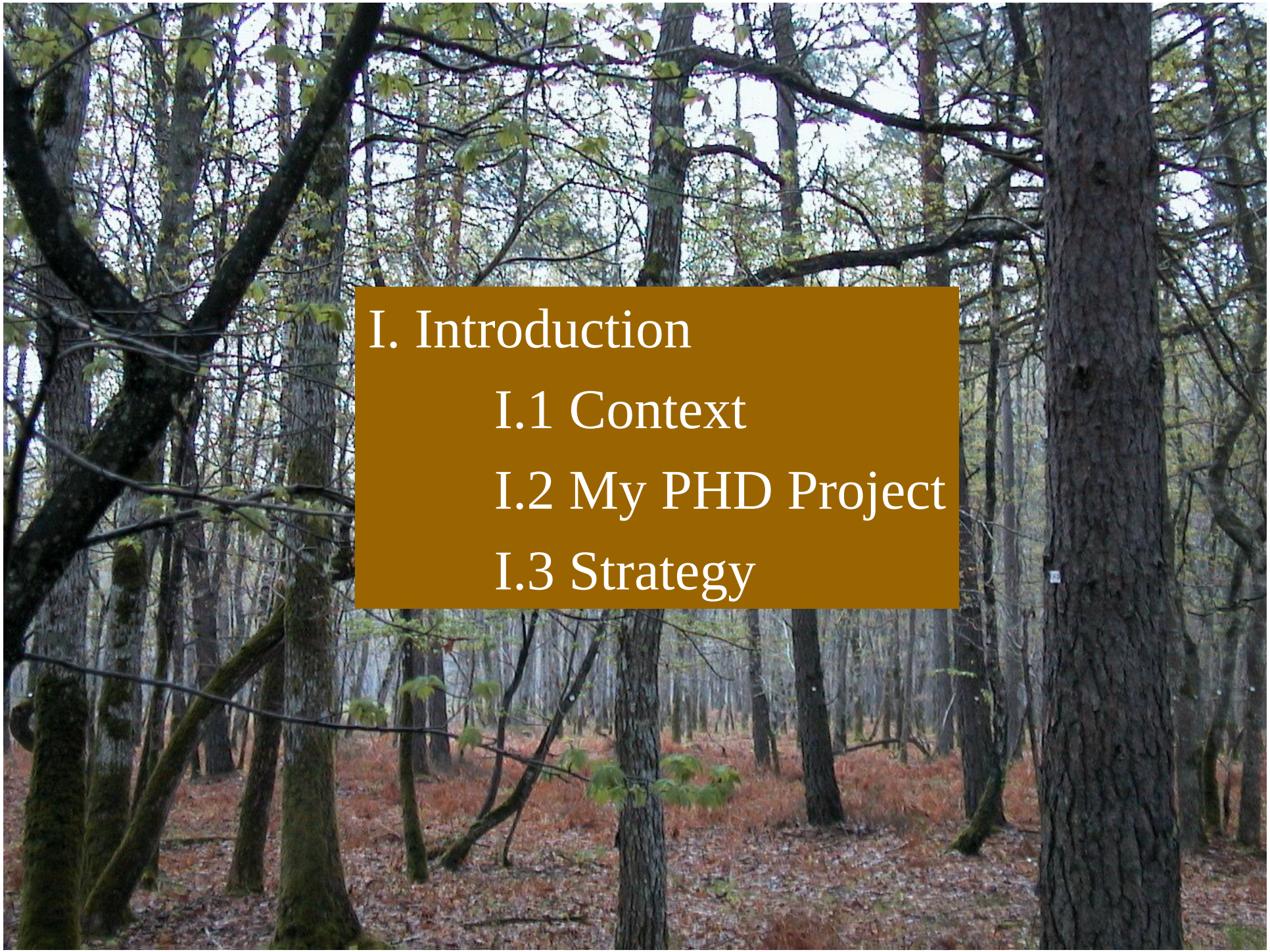
II. The Orleans forest

III. Spatial structure analysis

IV. Results : Oak and Scots pine mixed stands typology

V. Prospect: spatial structure modelling

VI. Conclusion


I. Introduction
I.1 Context
I.2 My PHD Project
I.3 Strategy

I.1 Context

Complex stands ⟺ Complex dynamics

(mixed and / or irregular)

Description ↓ Growth modelling ↓

Individual Based Model

(IBM)

I.1 Context

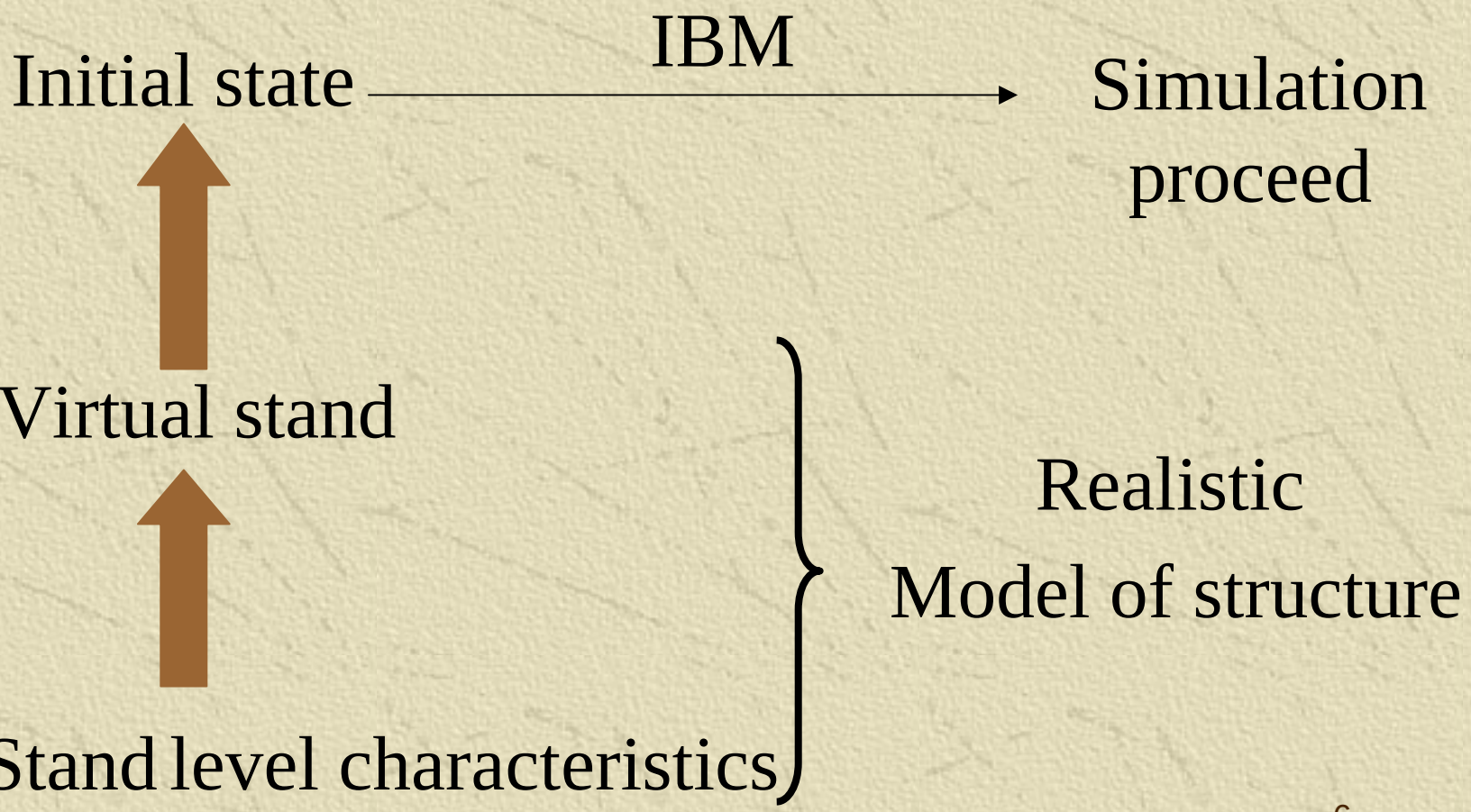
- For complex stands:

Initial state —IBM→ Simulation proceed

Description (species, circumference, height)
Location (local environment) of each tree

I.1 Context

- For complex stands:



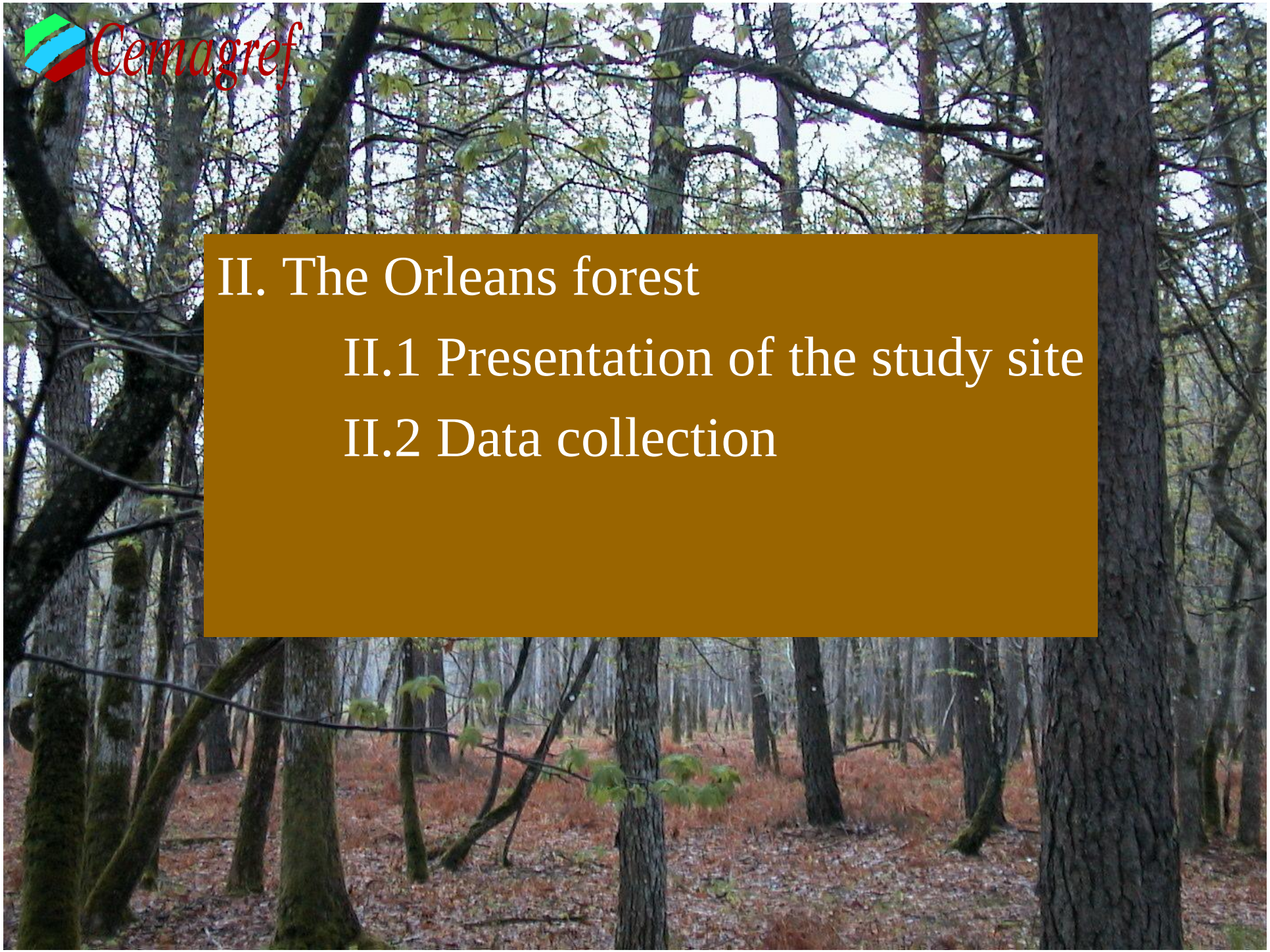
I.2 My PHD Project

- Build a realistic model of structure
- Illustrate it on mixed stands sessile oak ***(Quercus petraea)*** – Scots-pine ***(Pinus sylvestris)*** of the Orleans forest

I.3 Strategy (and aim of my presentation)

- Study and characterize precisely the studied stand spatial structure
- Identify spatial types
- Build a model of structure for each types

(Reconstruction of real identified spatial types)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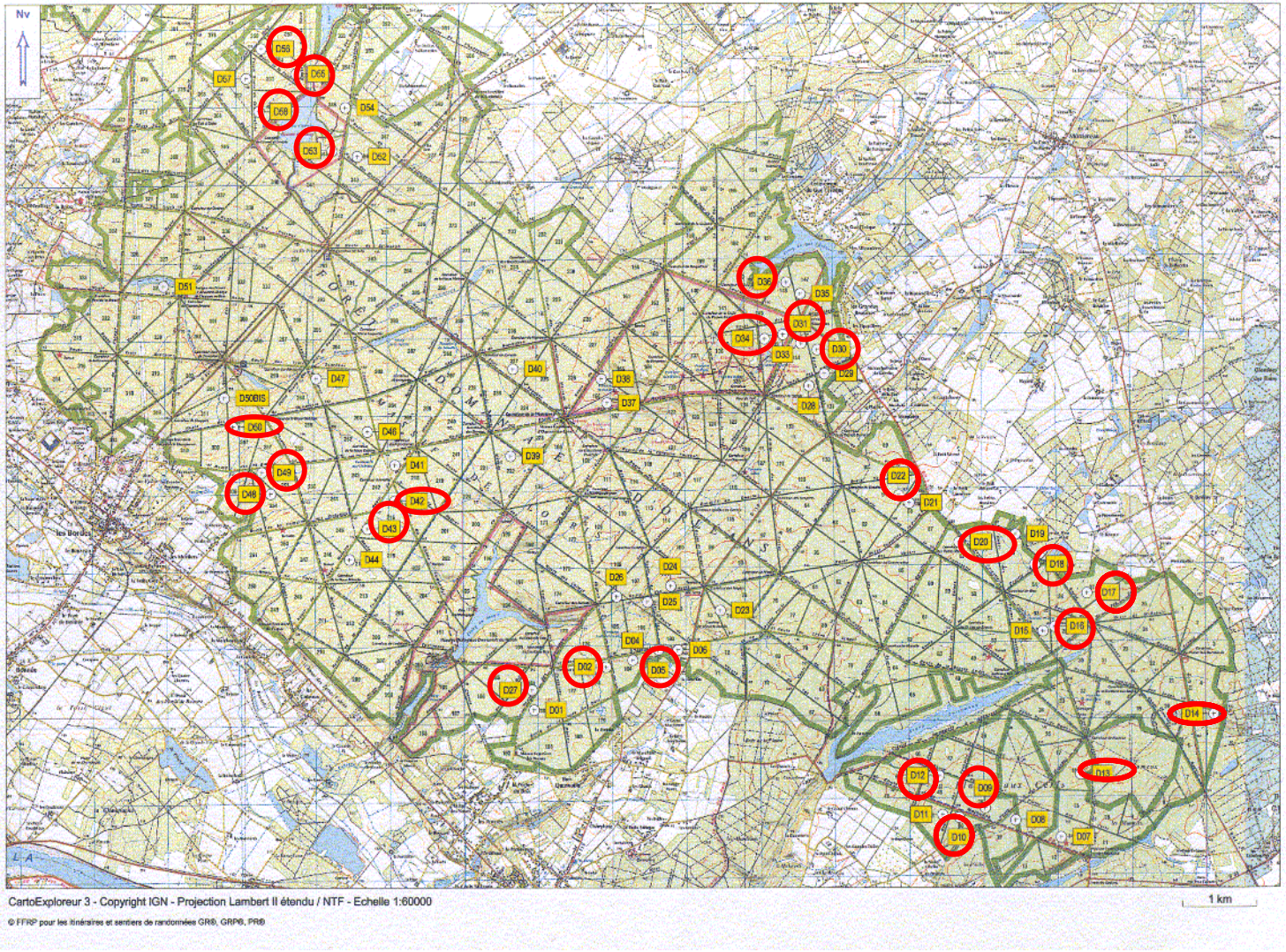
II. The Orleans forest
II.1 Presentation of the study site
II.2 Data collection

The Orleans forest

II.1 Study site.

The Orleans forest

II.1 Study site.



26 * 1 ha mapped plots

II.2 Data collection

- For each tree (C >=23cm)

distance

angle

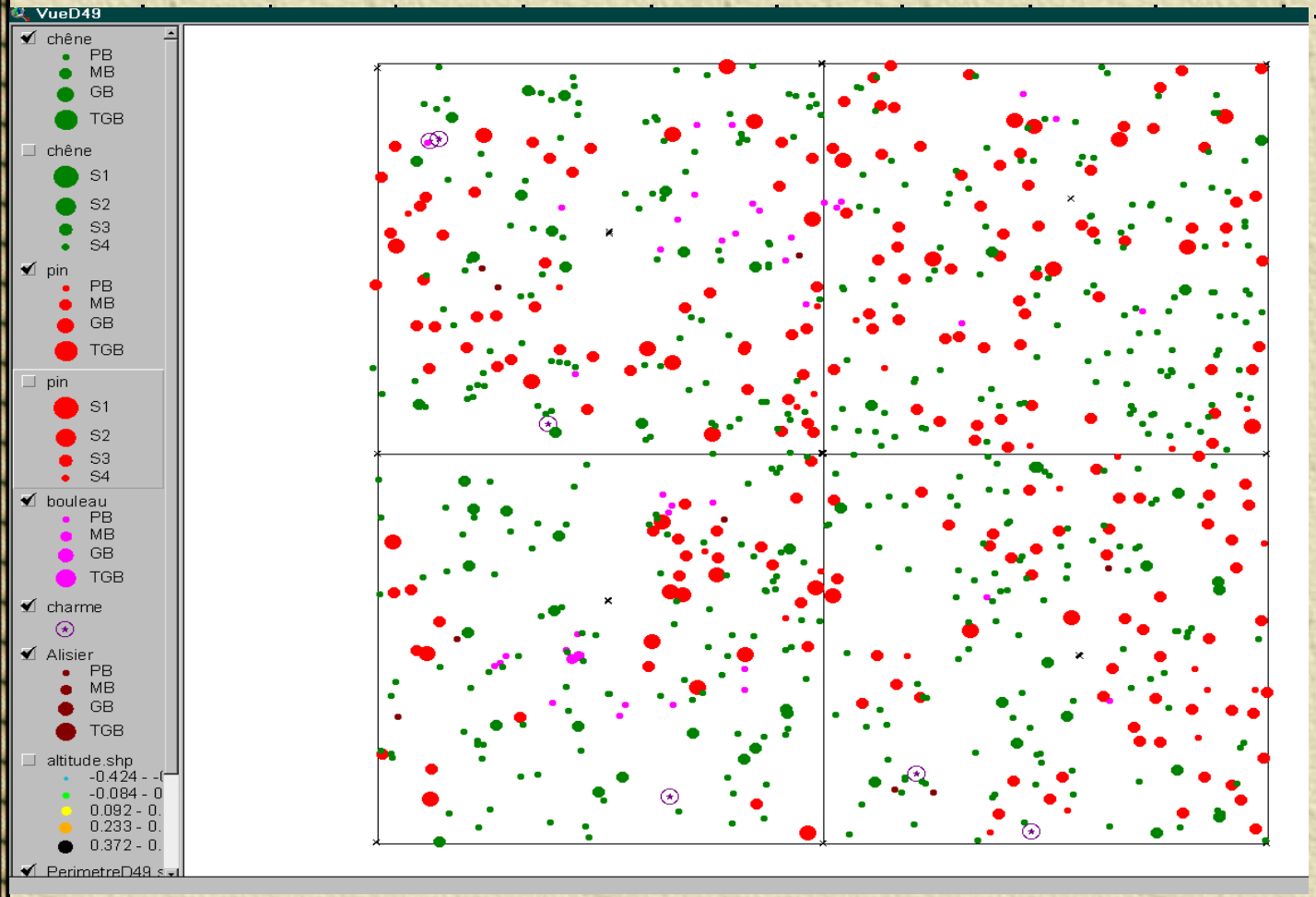
Theodolite

Prism

Species name
Circumference
Relative height

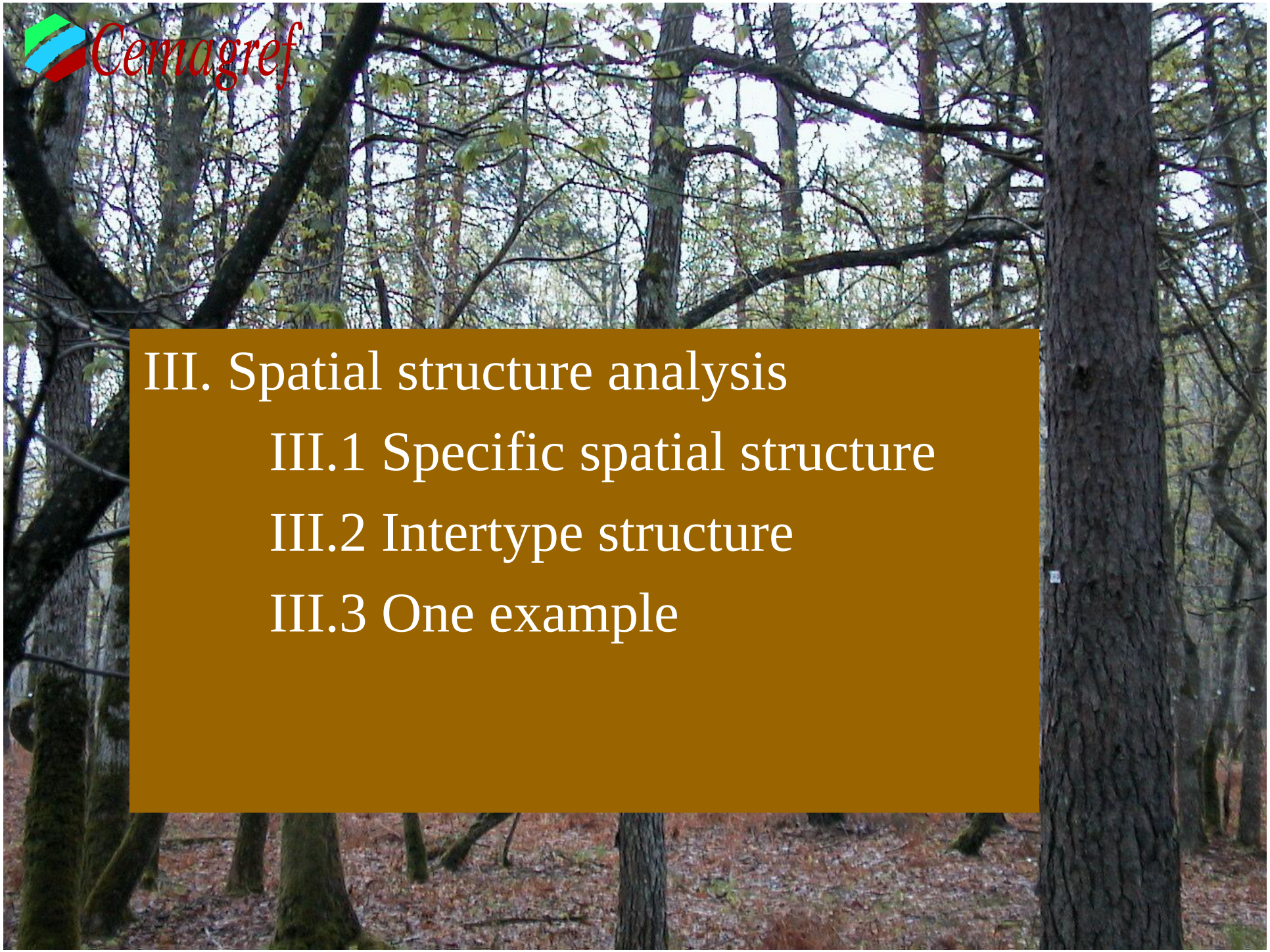
The Orleans forest

II.2 Data collection



26 maps of

1ha plots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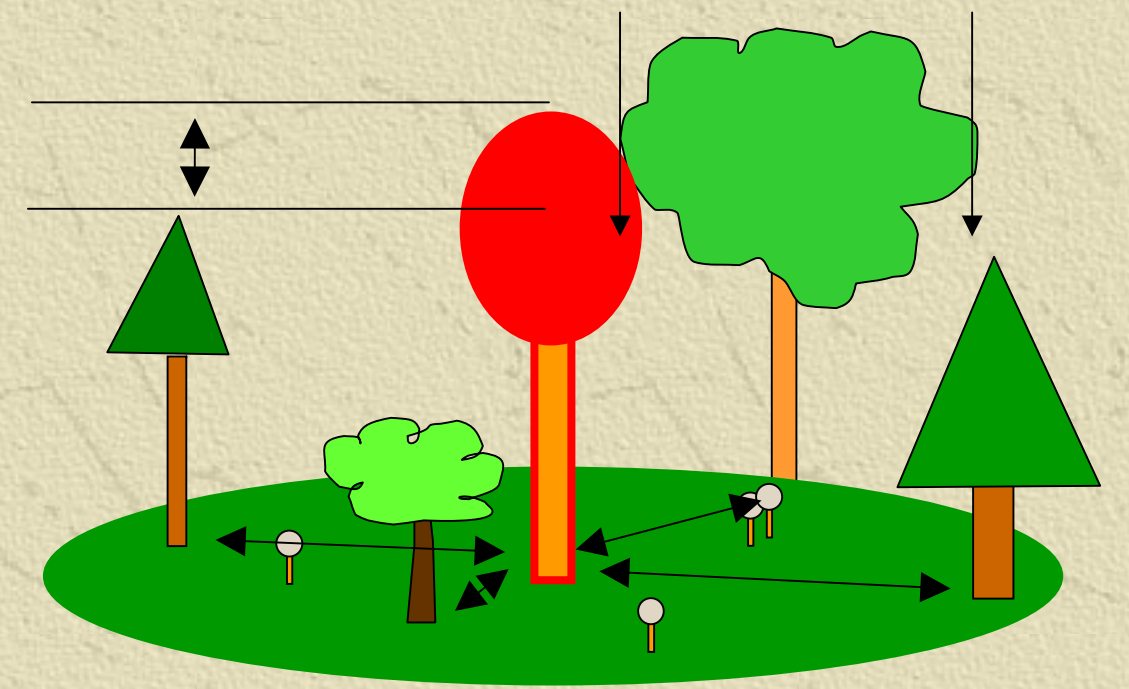
III. Spatial structure analysis
III.1 Specific spatial structure
III.2 Intertype structure
III.3 One example

Spatial structure analysis

- Arrangement of trees in space

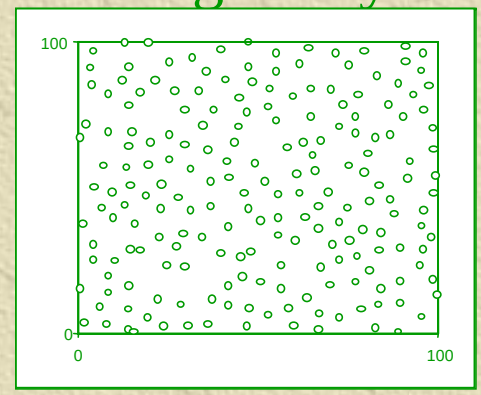


III.1 specific spatial structure

- Spécific structure by L(r) function (Besag in Ripley, 1977)

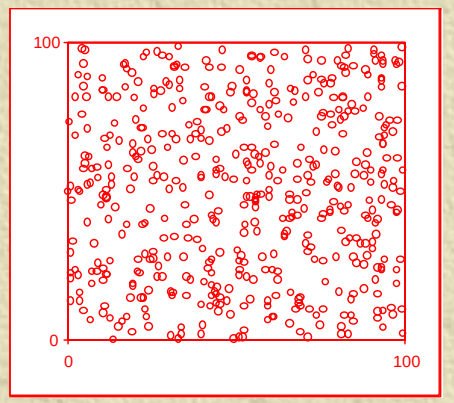
$$L(r) = (K(r)/\pi)^{1/2} - r$$

Regularity



$L(r) < 0$

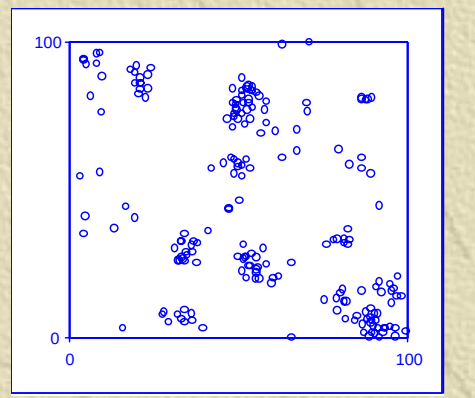
random



$L(r) = 0$

$K(r) = \pi r^2$

Aggregation

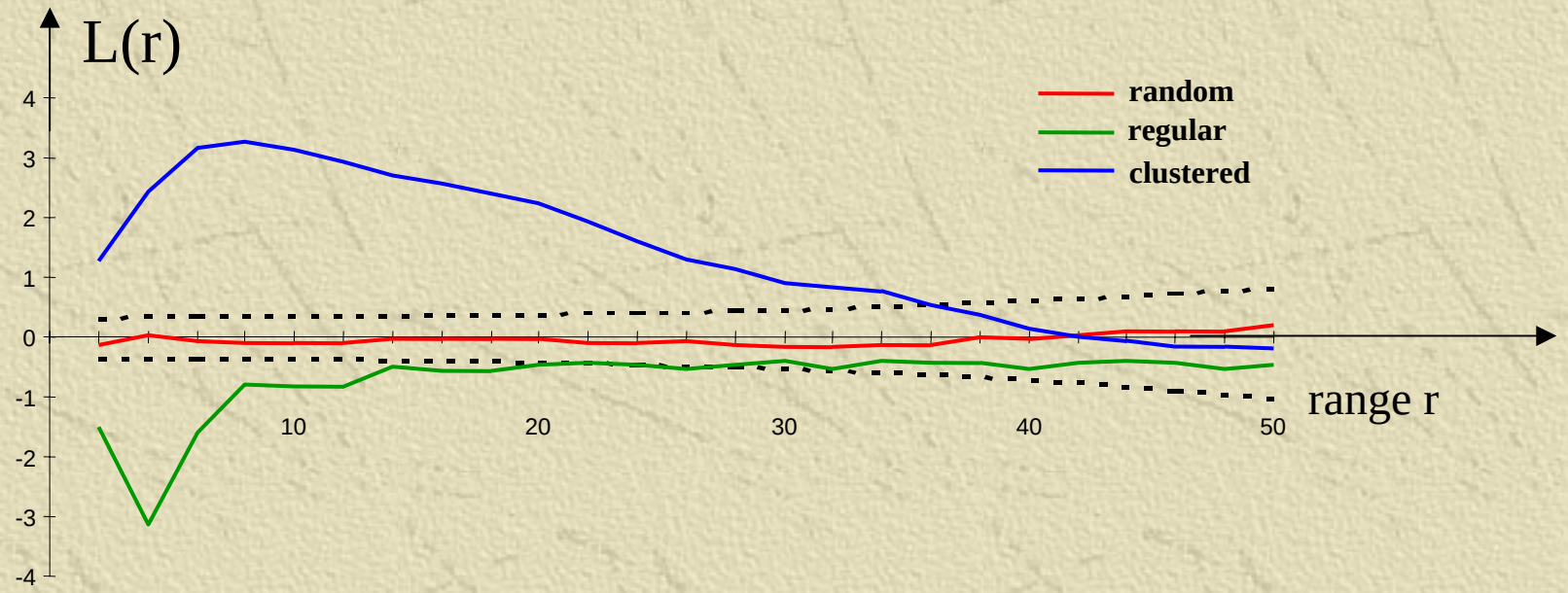


$L(r) > 0$

III.1 specific spatial struture

- Specific structure by L(r) function (Besag in Ripley, 1977)

$$L(r) = (K(r)/\pi)^{1/2} - r$$



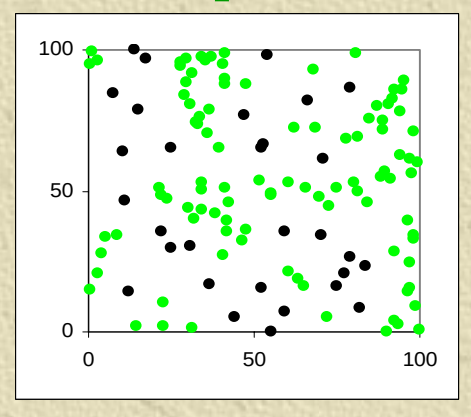
III.2 Intertype structure

Interaction structure by $L_{12}(r)$ function

(Lotwick and Silvermann, 1982).

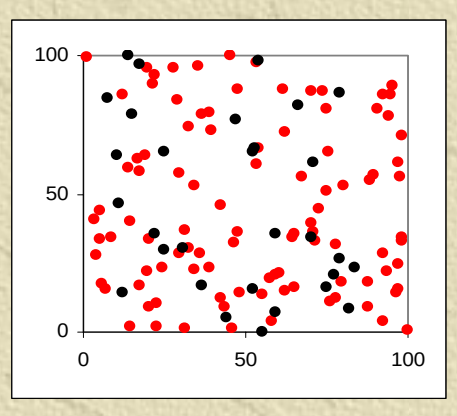
$$L_{12}(r) = (K(r)/\pi)^{1/2} - r$$

Repulsion



$L_{12}(r) < 0$

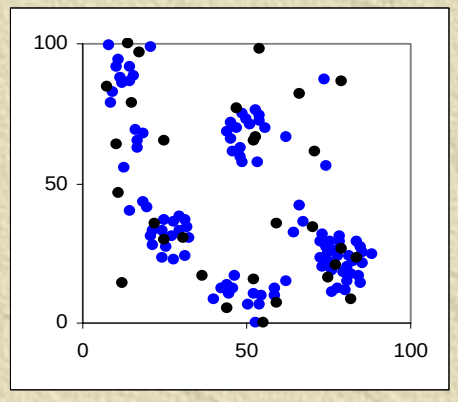
Independence



$L_{12}(r) = 0$

$K_{12}(r) = \pi r^2$

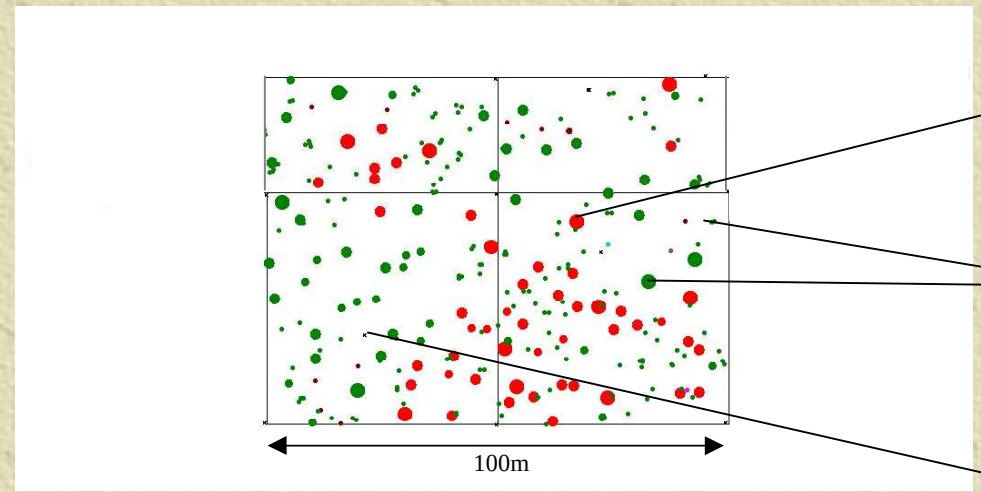
Attraction

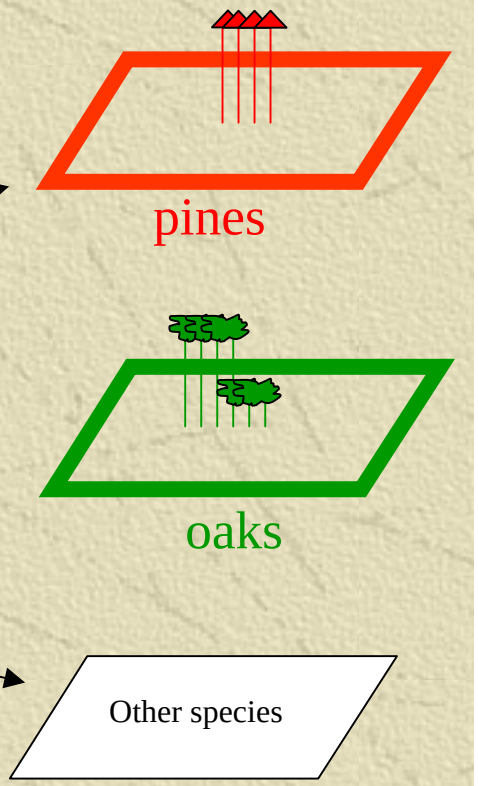


$L_{12}(r) > 0$

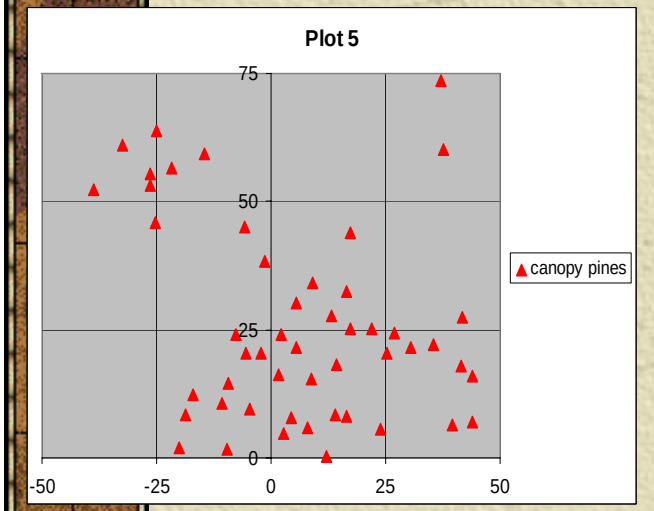
III.3 one example

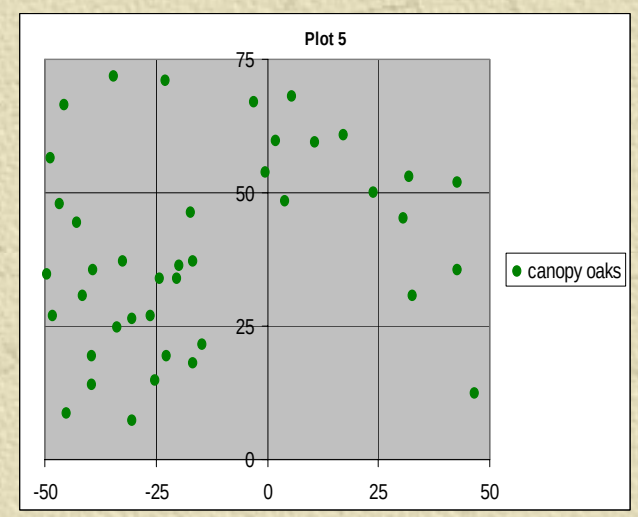
- Defining sub-populations:

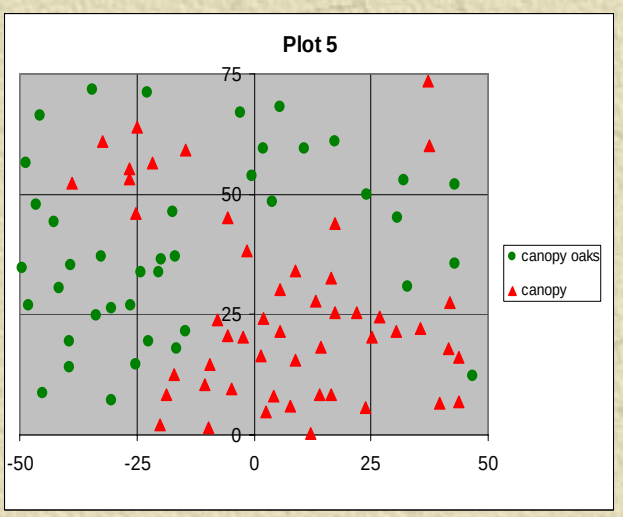




III.3 one example.



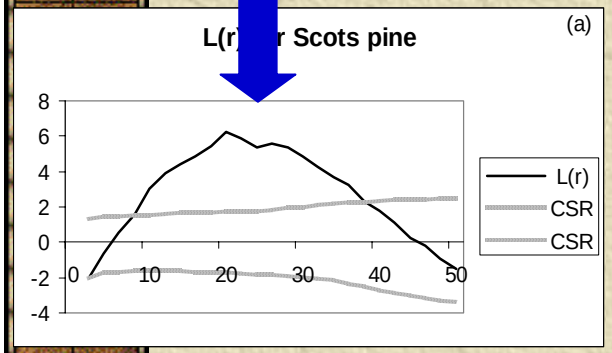


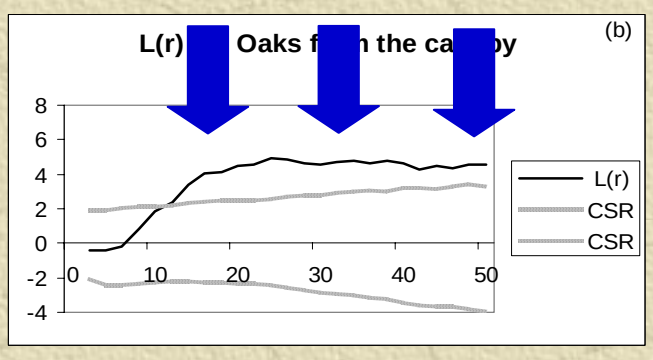


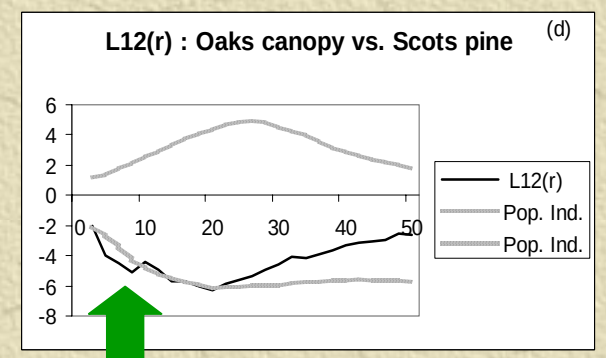
aggregation

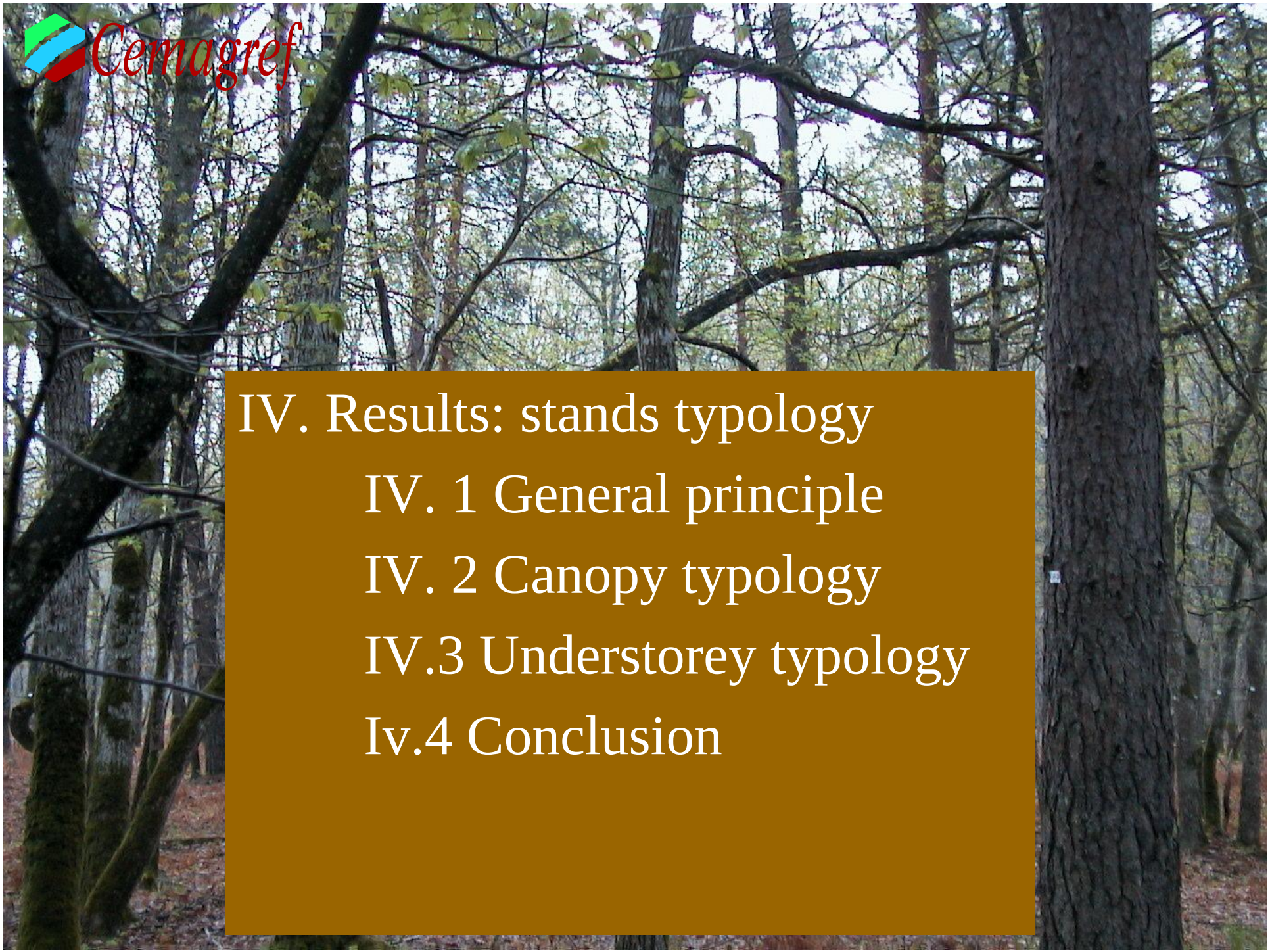
aggregation

repulsion









IV. Results: stands typology

IV. 1 General principle

IV. 2 Canopy typology

IV.3 Understorey typology

Iv.4 Conclusion

IV.1 General principle

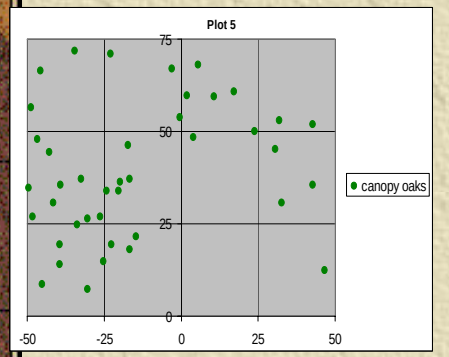
- Putting together plots with similar spatial characteristics
  - aggregation \ Random\ regularity
  - attraction \ independence\ repulsion
- Separate canopy from understorey

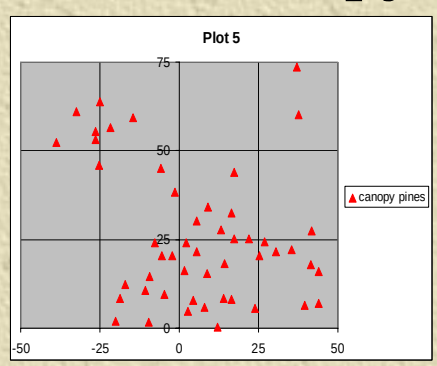
IV.1 General principle

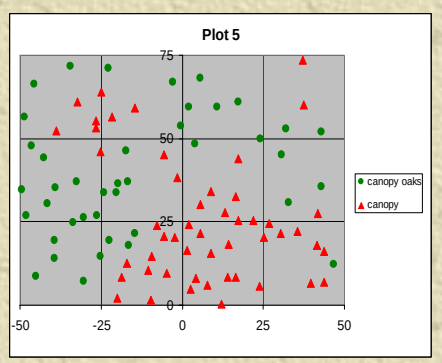
- Typology: putting together plots with similar spatial characteristics

1- for canopy

- Specific spatial structure of canopy oaks
- Specific spatial structure of canopy pines
- Intertype structure canopy oaks-canopy pines





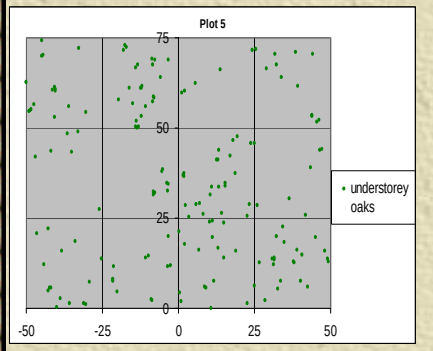


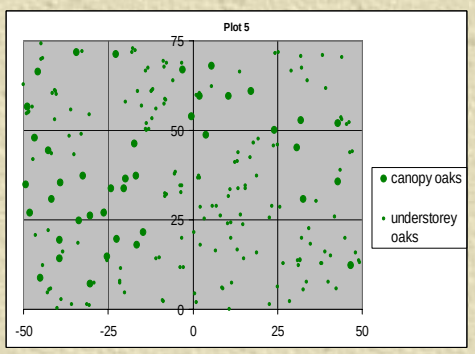
IV.1 General principle

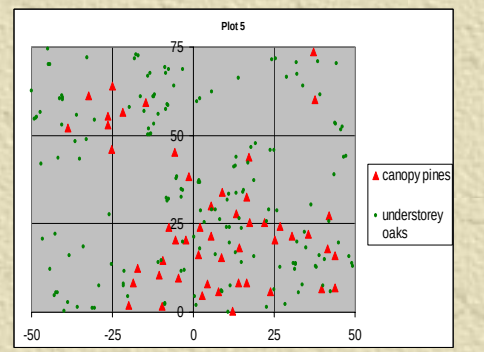
- Typology: putting together plots with similar spatial characteristics

2- for understorey

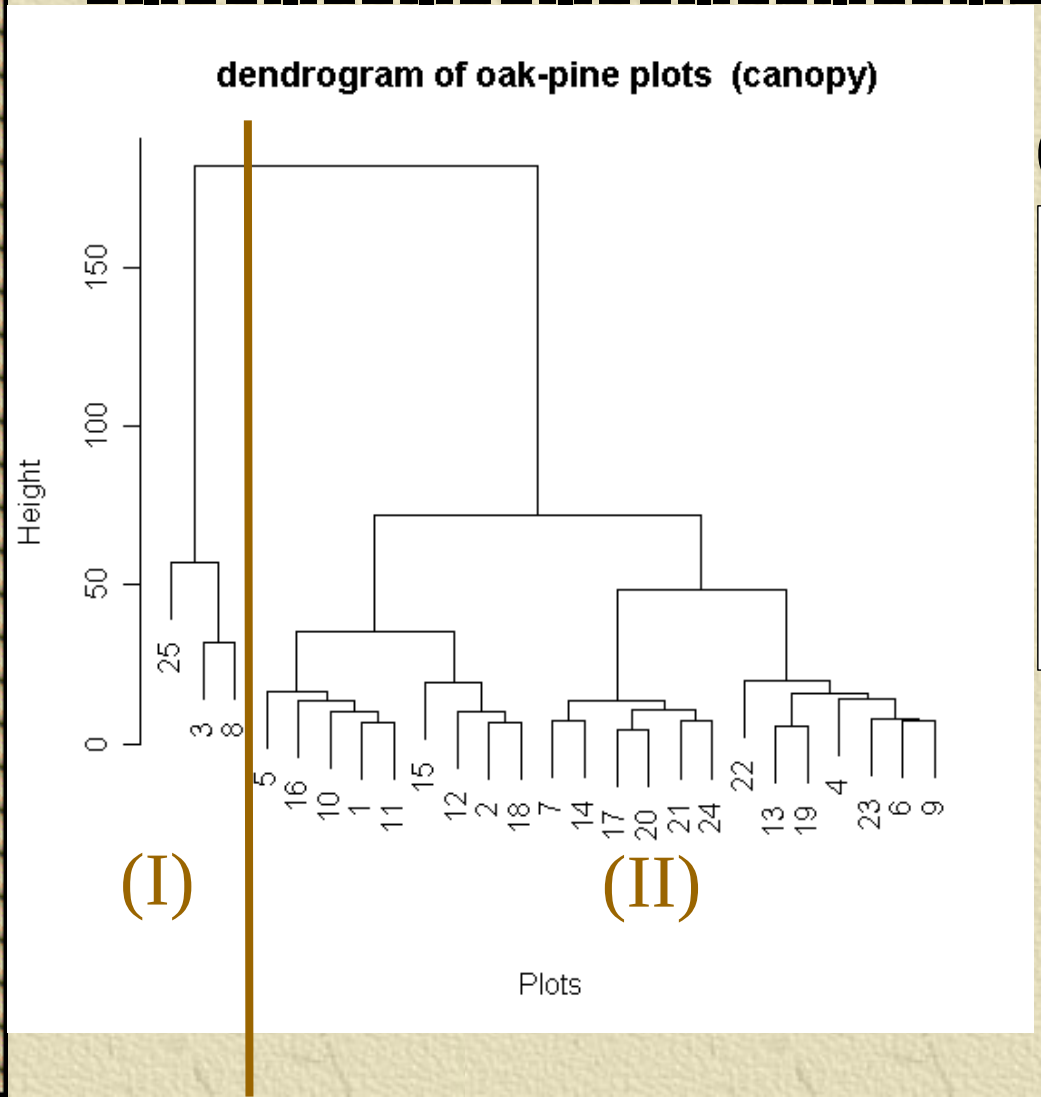
- Specific spatial structure of understorey oaks
- Intertype structure understorey oaks-canopy oaks
- Intertype structure understorey oaks-canopy pines



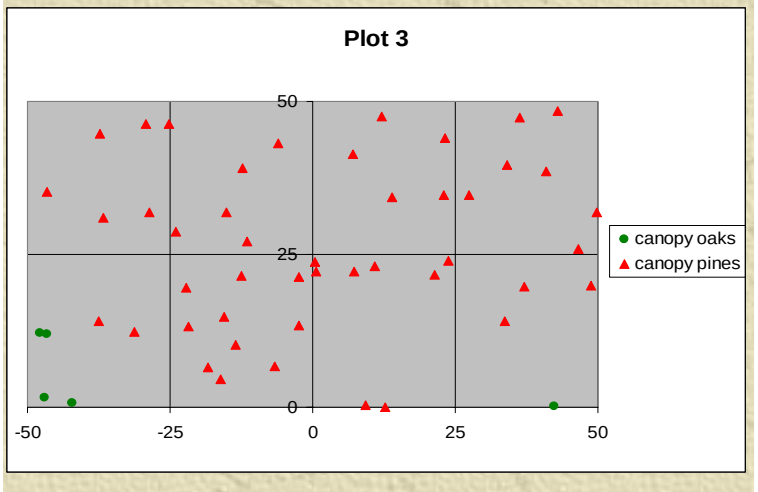




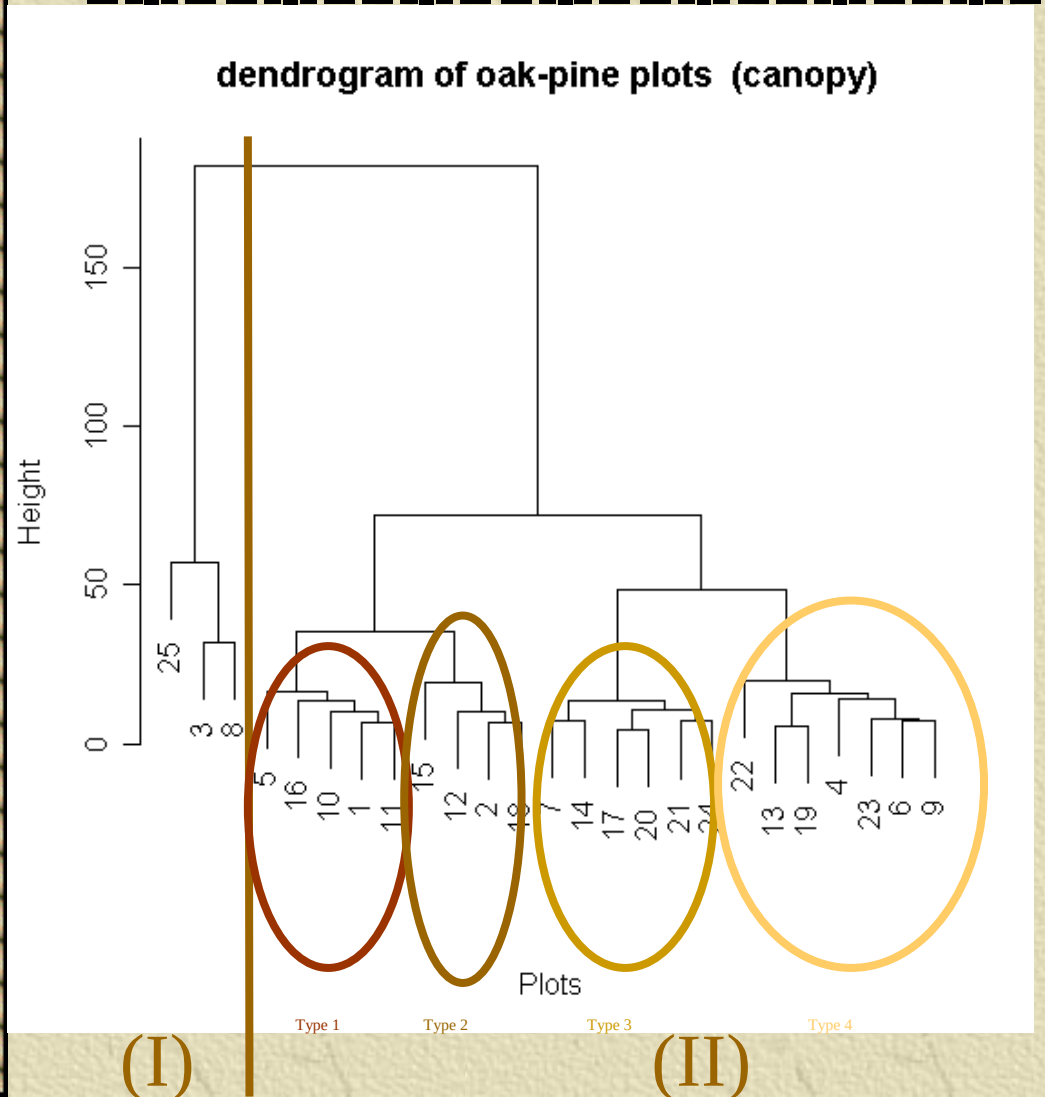
IV.2 Canopy typology



(I) canopy pine
(oak in understorey)

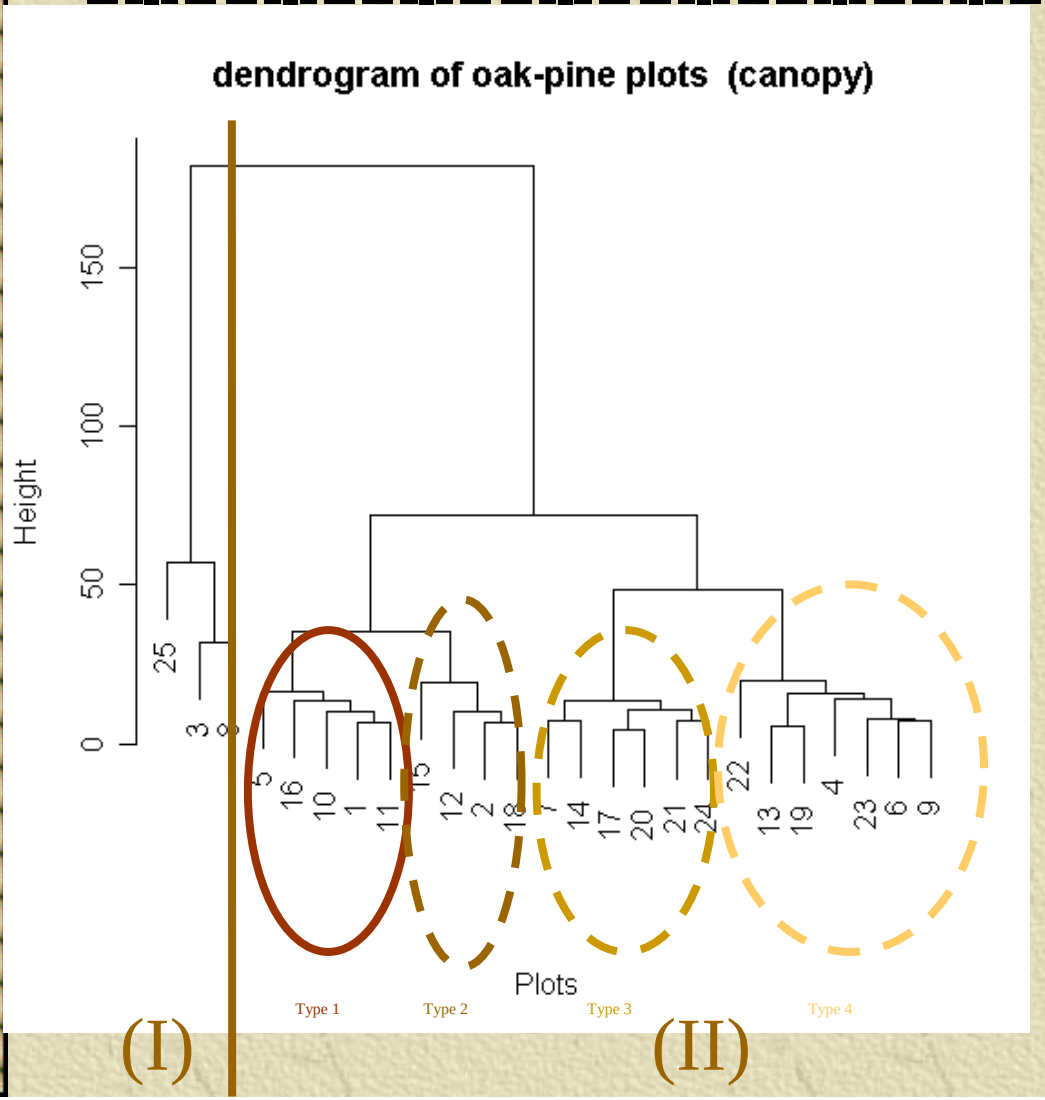


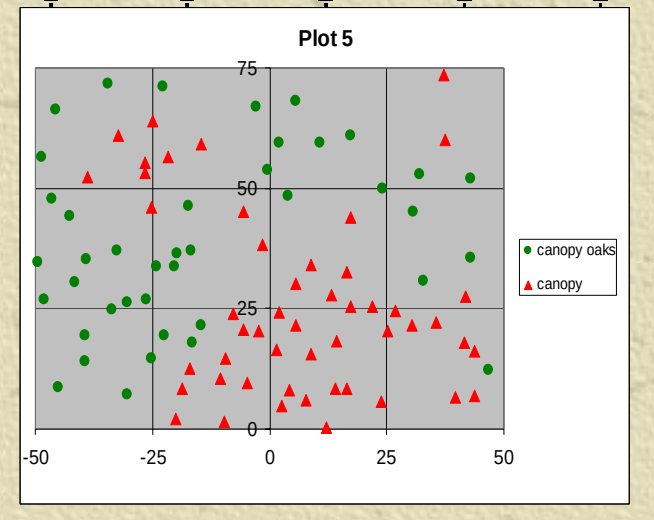
IV.2 Canopy typology



(II) oak - pine canopy

IV.2 Canopy typology

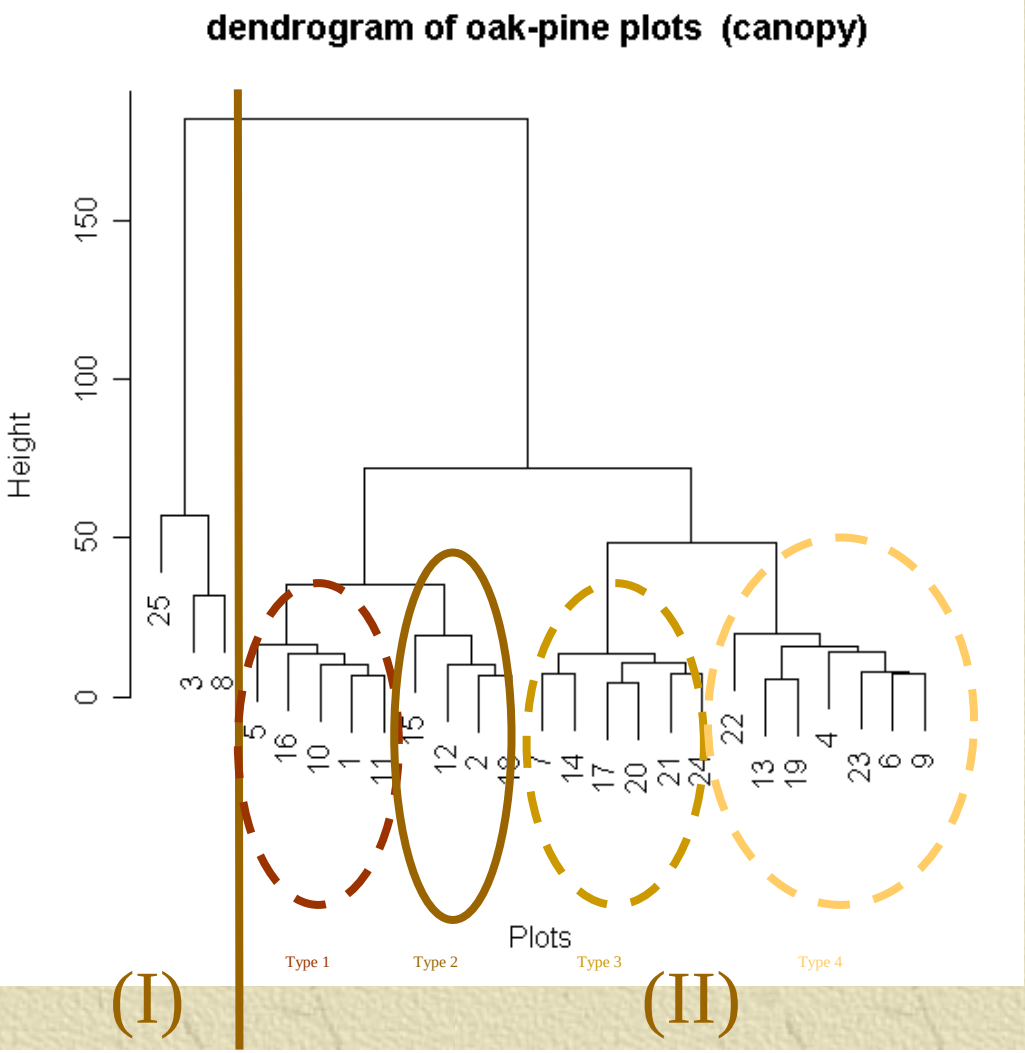


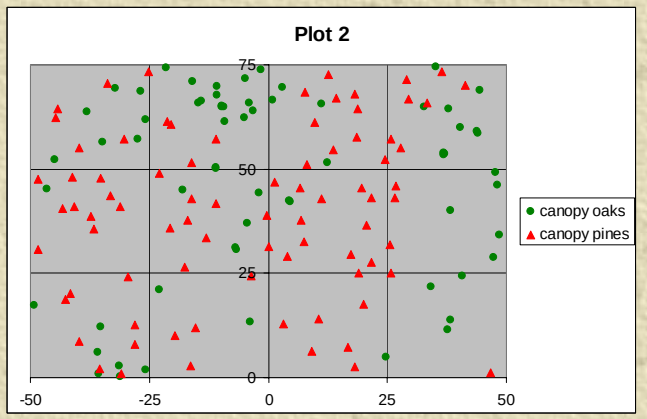


Type 1:

- Strong aggregation for oaks and pines
- repulsion

IV.2 Canopy typology

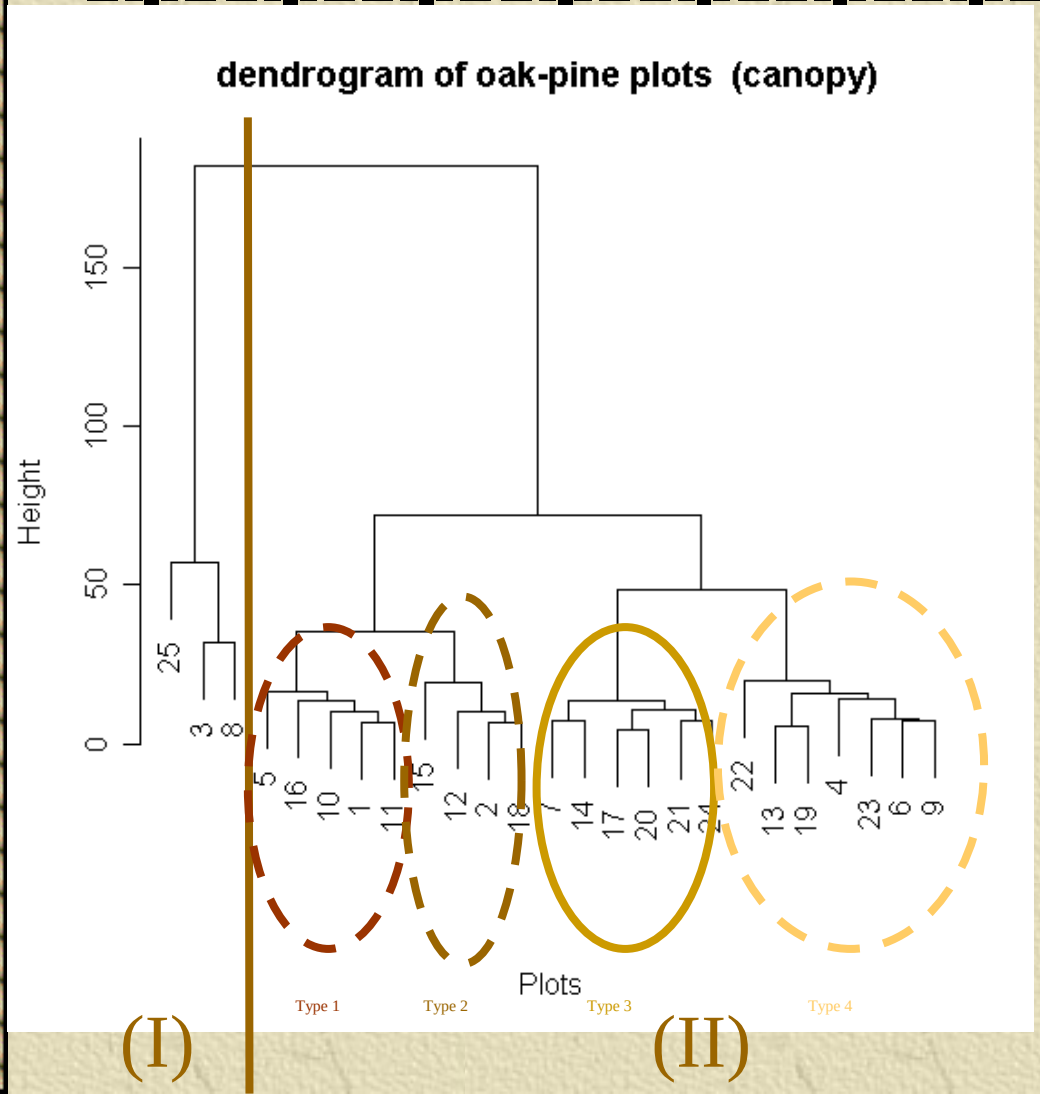


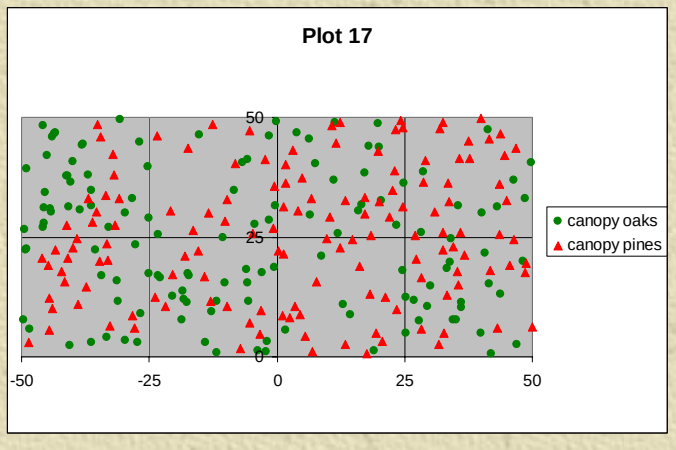


Type 2:

- Aggregation for oak and pine (less)
- Repulsion (less)

IV.2 Canopy typology

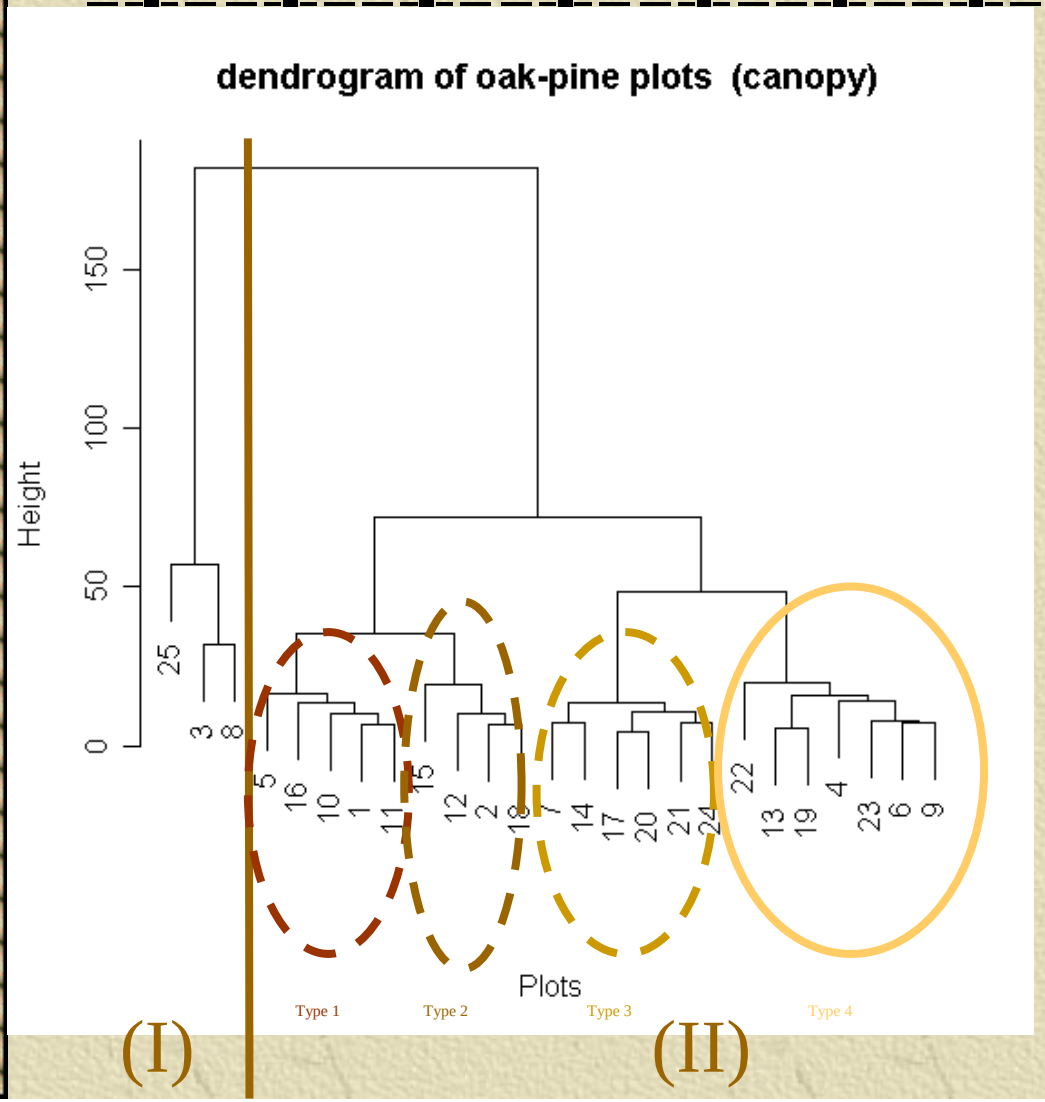


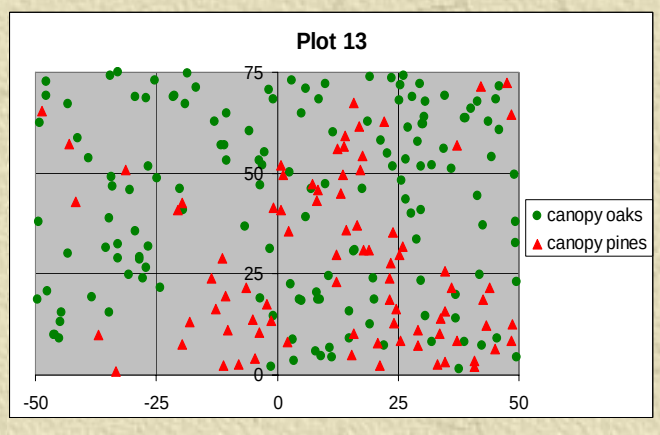


Type 3:

- Random structure for oak and pine
- independence

IV.2 Canopy typology

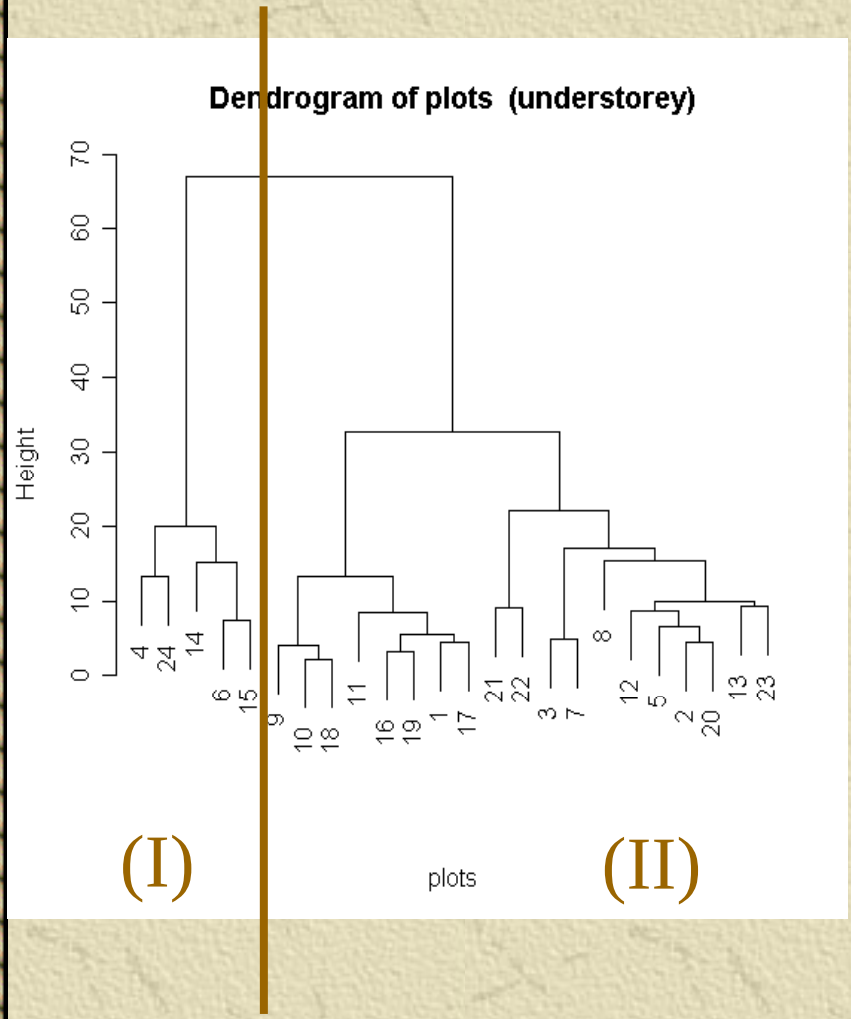




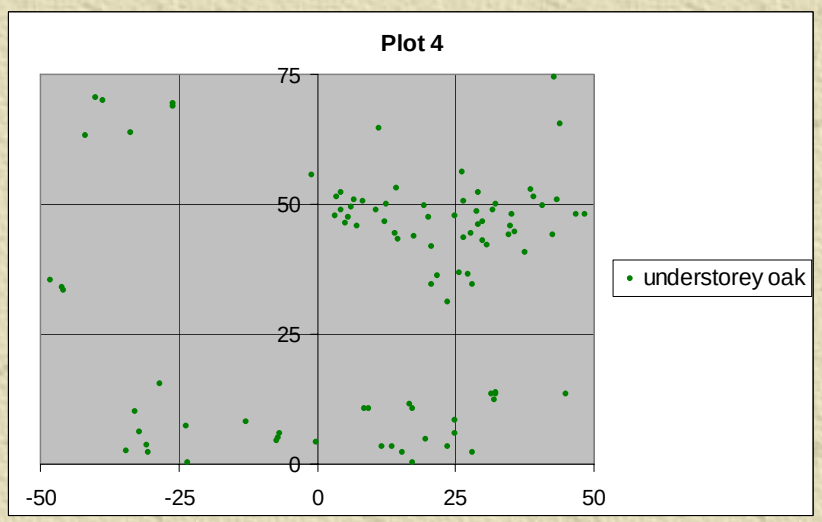
Type 4:

- Random structure for oak; agregation for pine
- Independence or slight repulsion

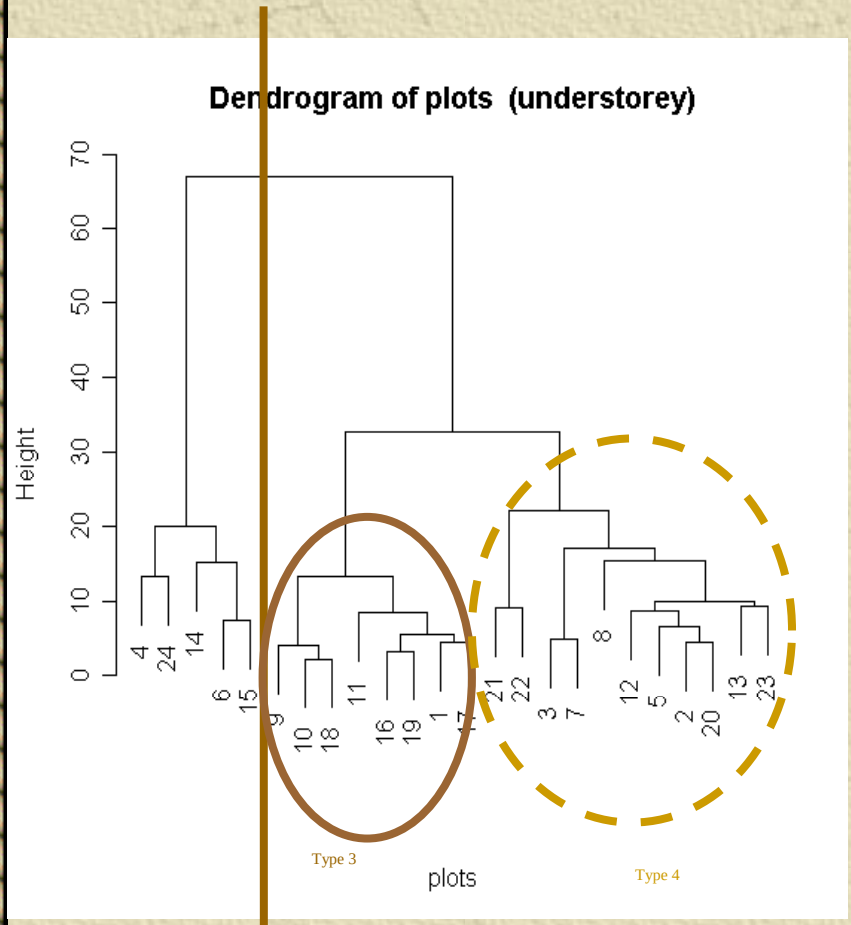
IV.3 Understorey typology



(I) aggregation for oaks



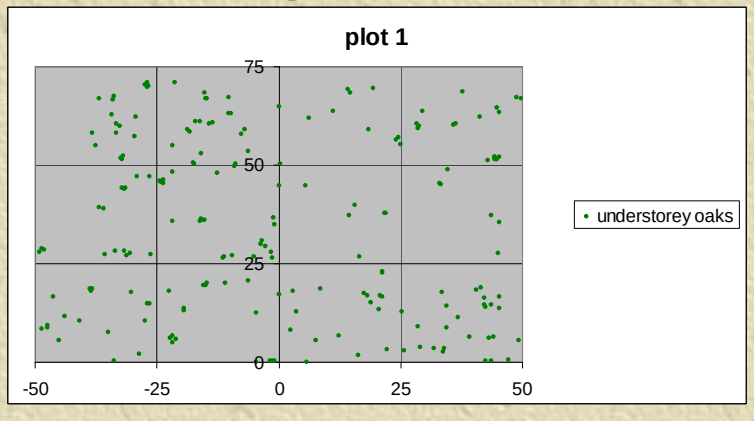
IV.3 Understorey typology

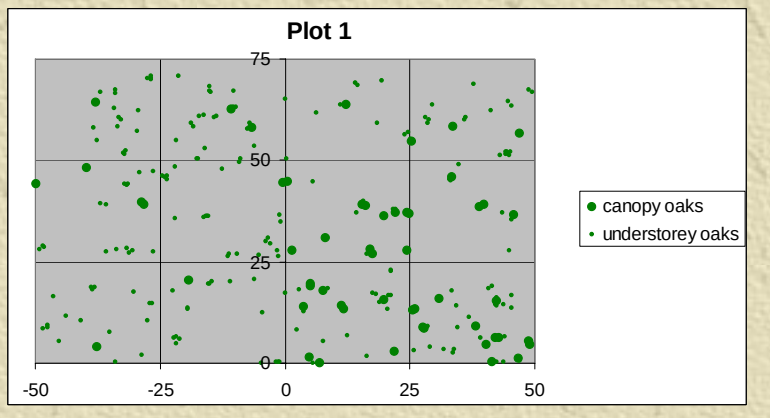


(I) (II)

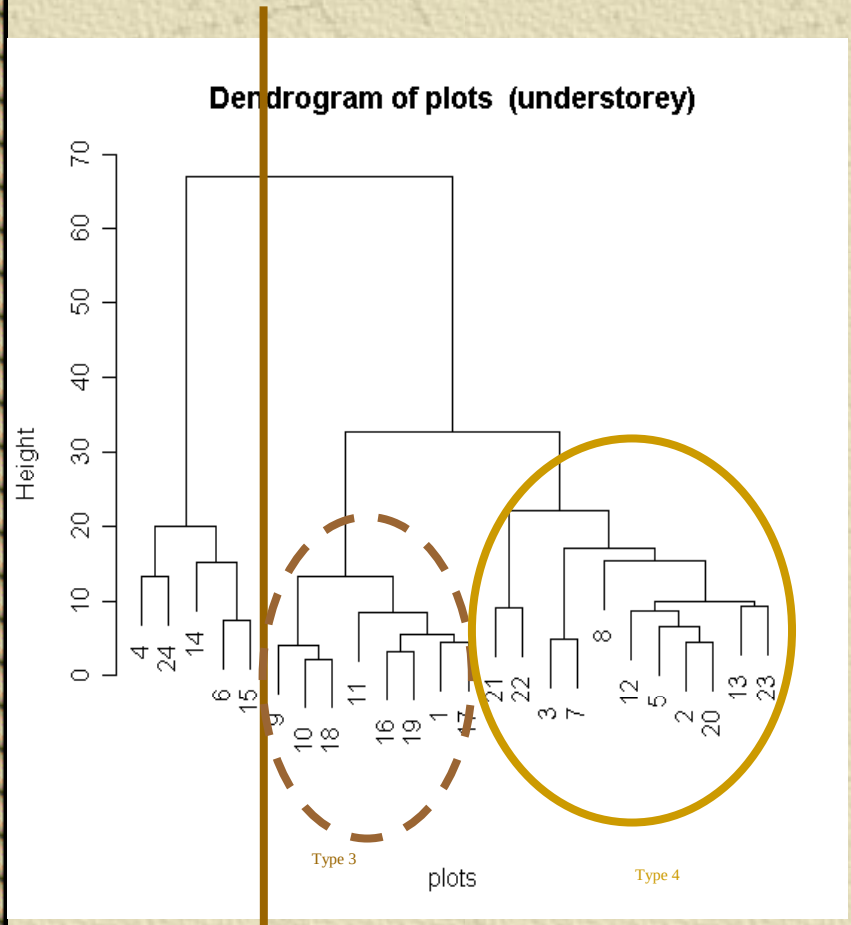
(II) less aggregation for oaks

Non significant attraction





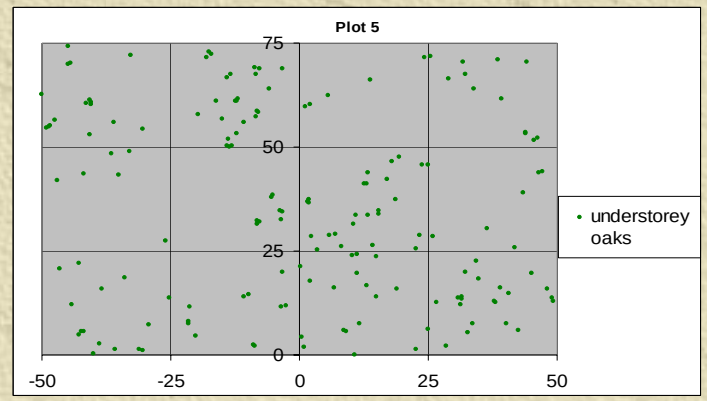
IV.3 Understorey typology

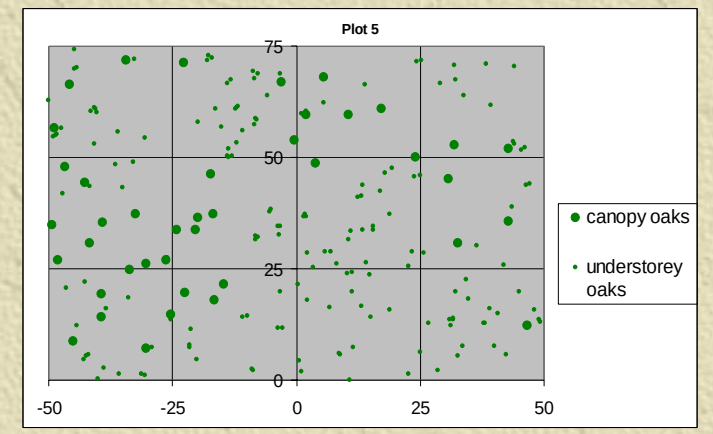


(I) (II)

(II) less aggregation for oaks

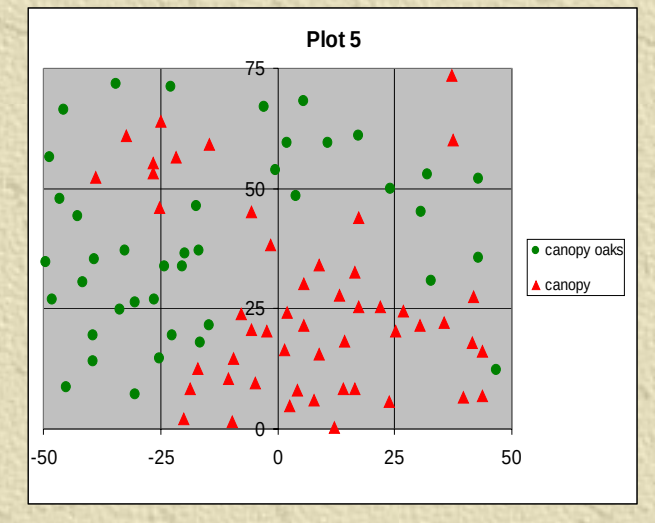
Non significant repulsion



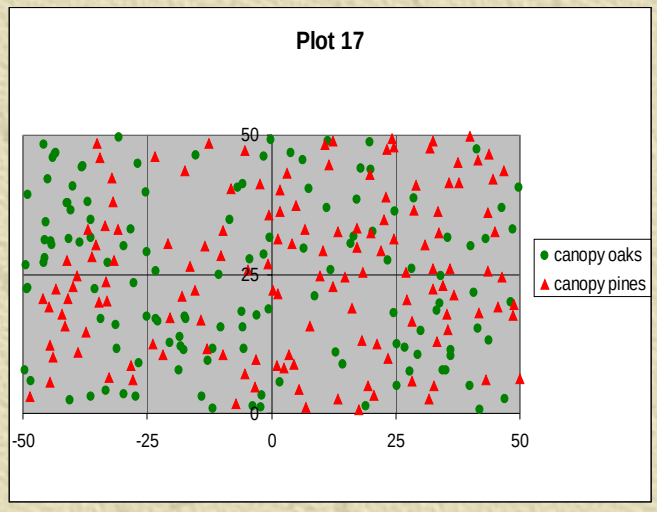


IV.4 Conclusion

- For canopy: a gradient



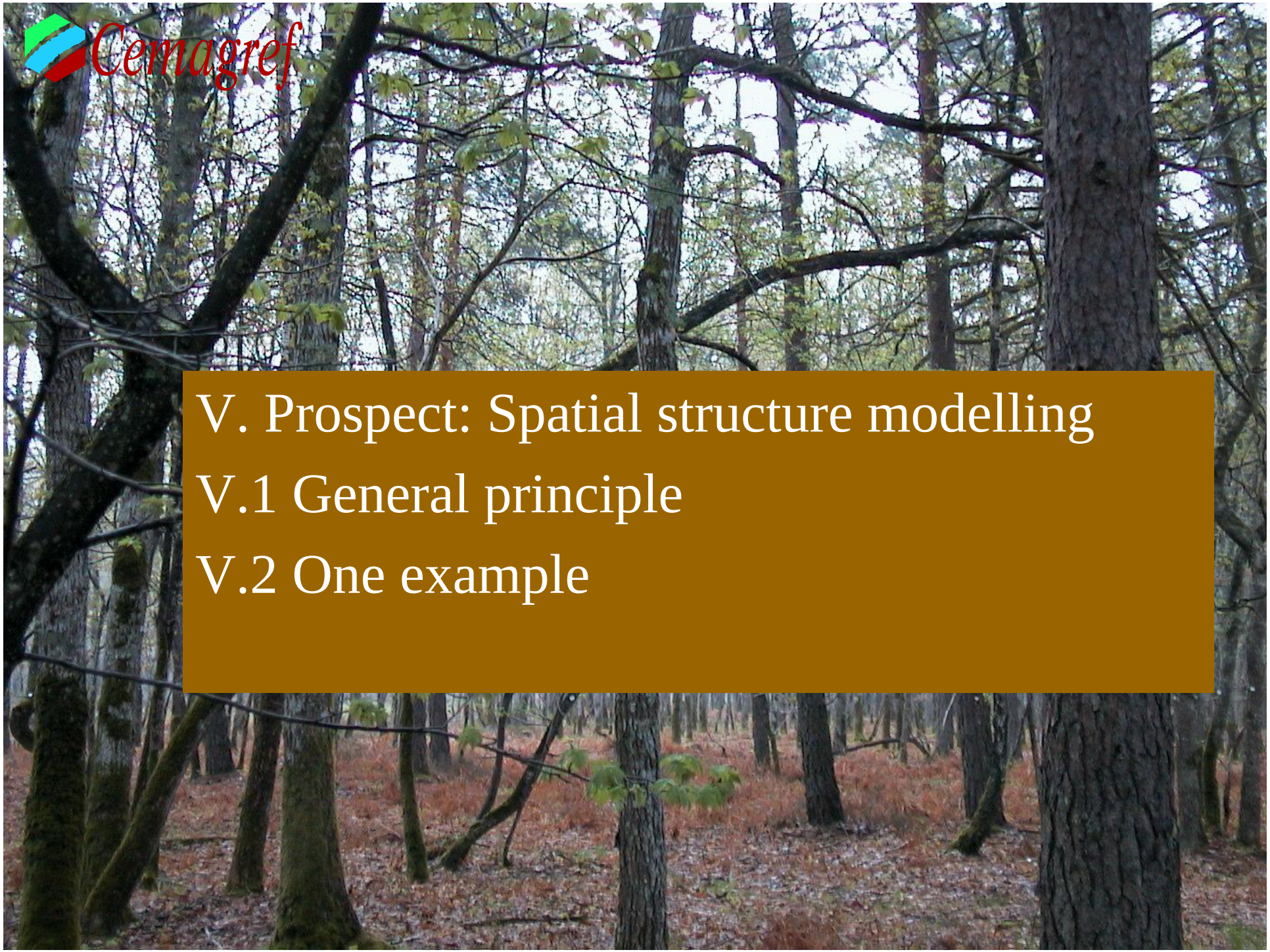
From aggregation….
From repulsion



…to random
…to independence

IV.4 Conclusion

- For Understorey:
  - aggregation (at different level) is the most common structure
  - Few or no intertype relations not differing significantly from independence.



V. Prospect: Spatial structure modelling

V.1 General principle

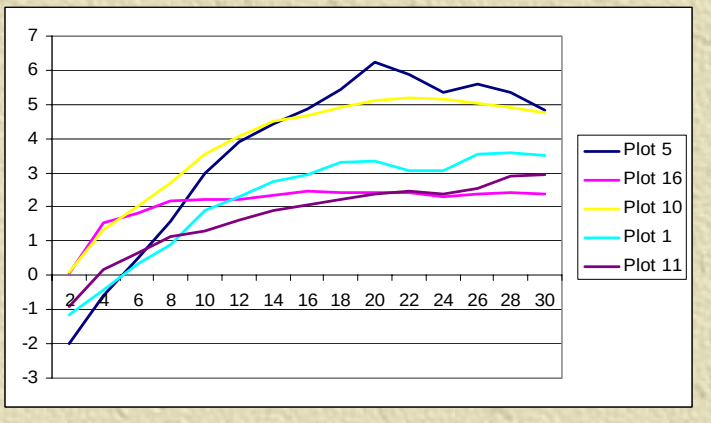
V.2 One example

V.1 General principle

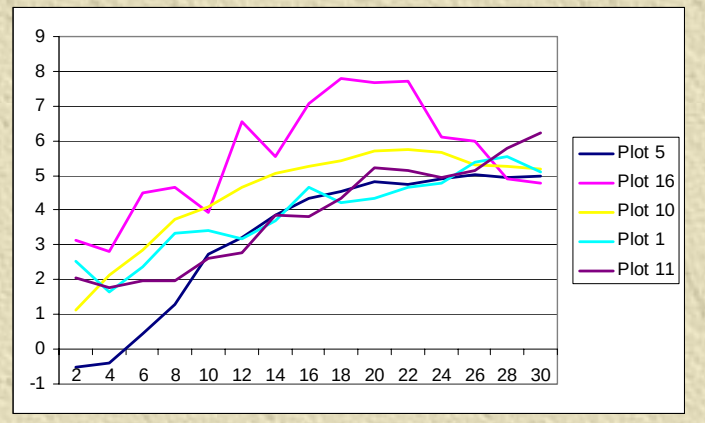
- Average spatial characteristics for each identified type
- Build of a model of spatial structure for each type

V.2 One example (on canopy trees)

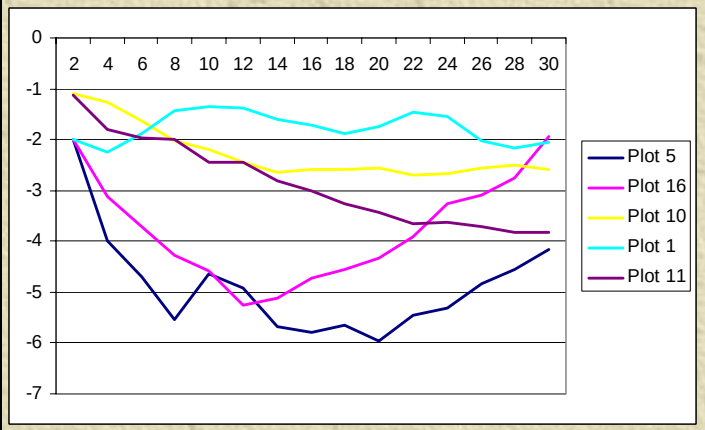
- Type 1:



L(r) for canopy pines



L(r) for canopy oaks



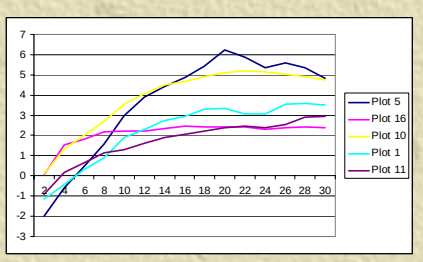
$L_{12}(r)$ between canopy oaks ans pines

V.2 One example (on canopy trees)

- Type 1:Average spatial characteristics
  - Aggregated spatial pattern of canopy oaks
  - Aggregated spatial pattern of canopy pines
  - Repulsive Intertype structure between canopy oaks and canopy pines
- Build of a model of spatial structure for type 1

V.2 One example (on canopy trees)

- Build of a model of spatial structure for type 1
  - Aggregated spatial pattern of canopy pines



L(r) for canopy pines

  - Reconctruction of spatial pattern by appropriate point processes (Diggle, 1983)

V.2 One example (on canopy trees)

- Build of a model of spatial structure for type 1
  - Aggregated spatial pattern of canopy pines
  - Reconctruction of spatial pattern by appropriate point processes

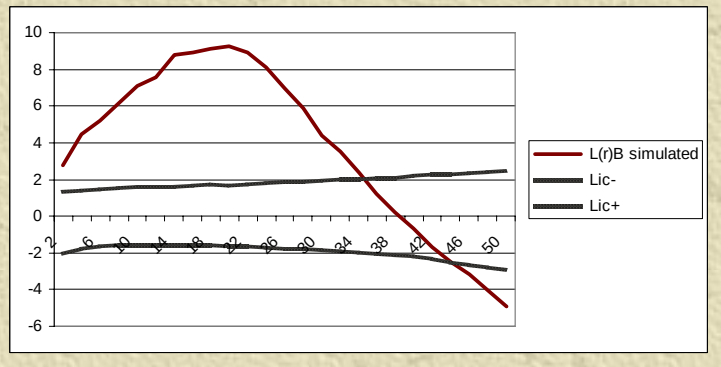
→ Neyman Scott process

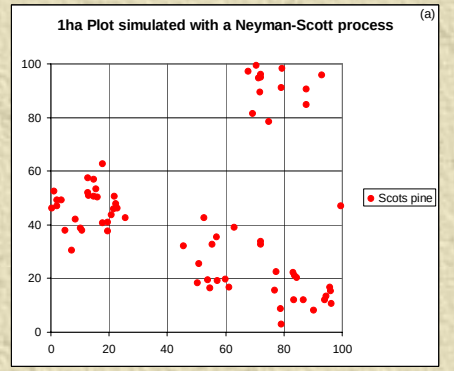
Parameters: - Number, radius and density of aggregates

V.2 One example (on canopy trees)

- Build of a model of spatial structure for type 1
  - Aggregated spatial pattern of canopy pines
  - Reconctruction of spatial pattern by appropriate point processes

→ Neyman Scott Process

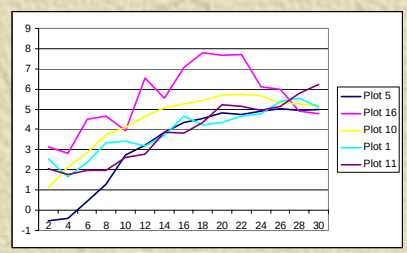




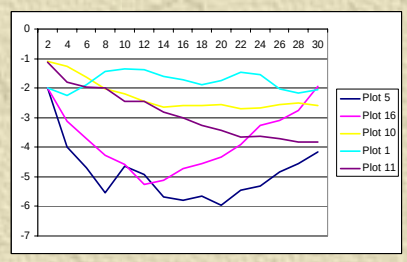
Simulated pattern

V.2 One example (on canopy trees)

- Build of a model of spatial structure for type 1
  - Aggregated spatial pattern of canopy oaks; intertype structure of repulsion



L(r) for canopy oaks



$L_{12}(r)$ canopy oaks / pines

  - Reconctruction of spatial pattern by appropriate point processes

V.2 One example

- Build of a model of spatial structure for type 1
  - Aggregated spatial pattern of canopy oaks; intertype structure of repulsion
  - Reconctruction of spatial pattern by appropriate point processes

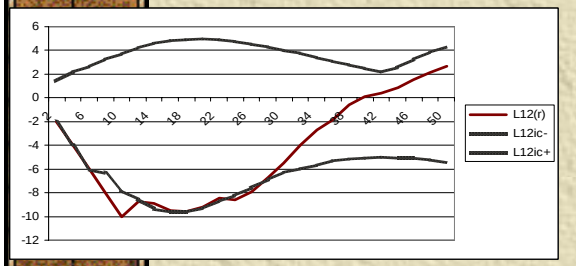
→ Interspecific gibbs proccess

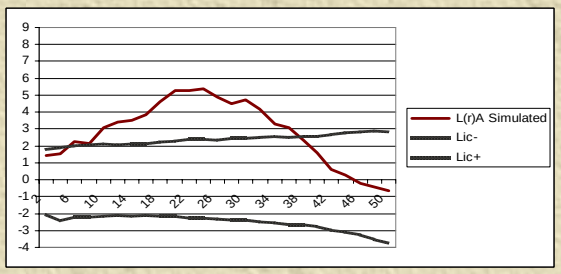
Parameters: - Number of points, minimal distance to pine

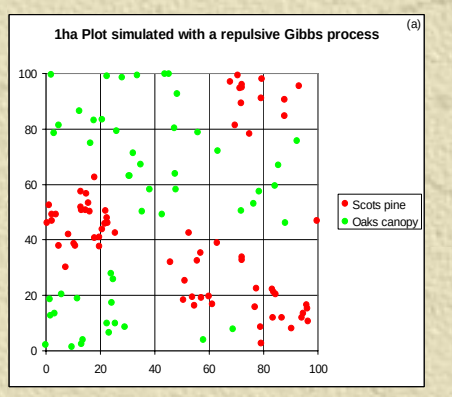
V.2 One example

- Build of a model of spatial structure for type 1
  - Aggregated spatial pattern of canopy oaks; intertype structure of repulsion
  - Reconctruction of spatial pattern by appropriate point processes (Diggle, 1983)

→ Interspecific gibbs proccess







Simulated pattern

VI. Conclusion

Conclusion

- Build of a typology of oak- Scots pine mixed stands
- A typology based on spatial structure
- 5 canopy and 3 understorey spatial types identified

Conclusion

For each types

- Spatial characteristics (individual description and local environment) that can be simulated
- Stand level characteristics (tree density, presence or absence of species in the understorey, basal area, diameter classes, few inter-tree distances)

Conclusion

For any stand

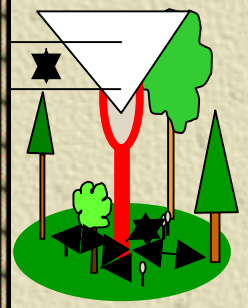
Inter-tree distance

Basal area

Tree density

Diameter classes

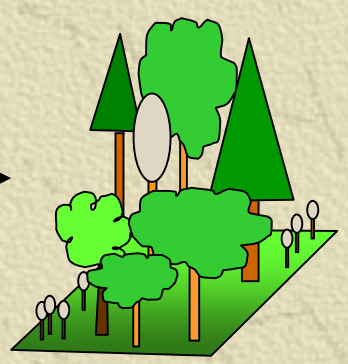
Stand level characteristics



Spatial structure analysis

Typology

Point process

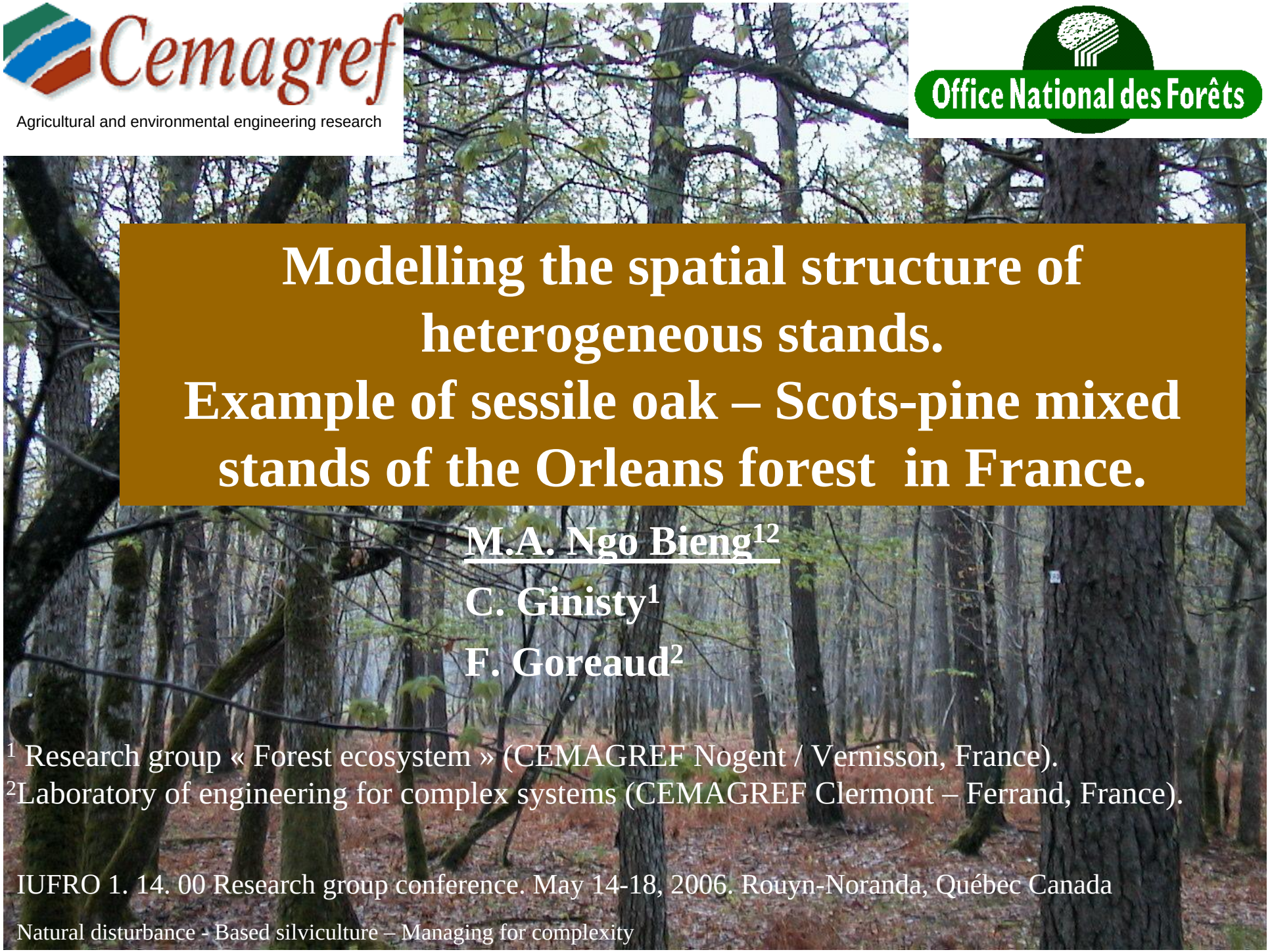


Experimental plots

Virtual stand

simulation

Results with IBM



Cemagref

Agricultural and environmental engineering research

Office National des Forêts

Modelling the spatial structure of heterogeneous stands. Example of sessile oak – Scots-pine mixed stands of the Orleans forest in France.

M.A. Ngo Bieng[12]

C. Ginisty[1]

F. Goreaud[2]

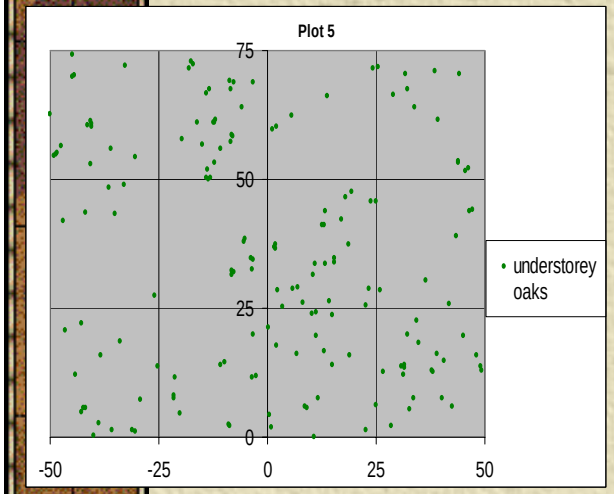
[1] Research group « Forest ecosystem » (CEMAGREF Nogent / Vernisson, France).

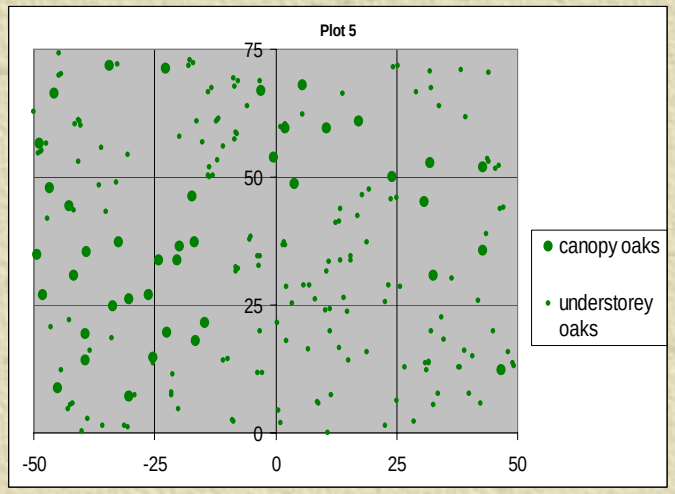
[2]Laboratory of engineering for complex systems (CEMAGREF Clermont – Ferrand, France).

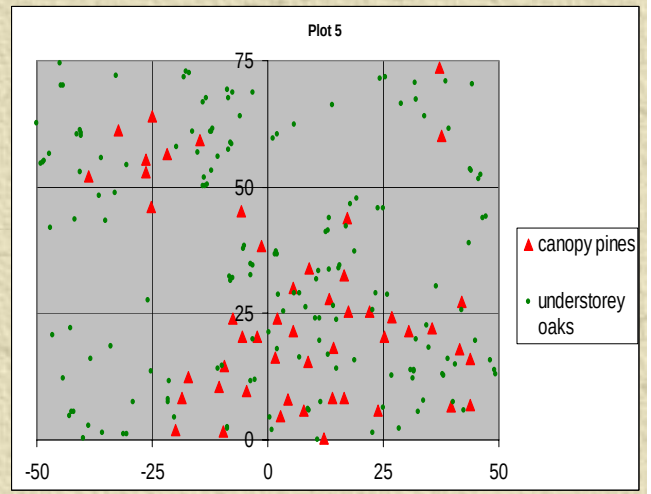
IUFRO 1. 14. 00 Research group conference. May 14-18, 2006. Rouyn-Noranda, Québec Canada

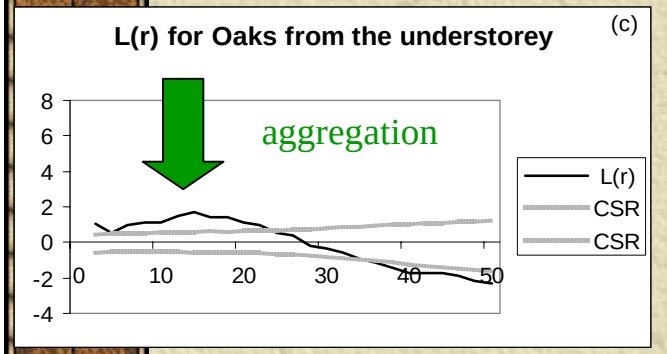
Natural disturbance - Based silviculture – Managing for complexity

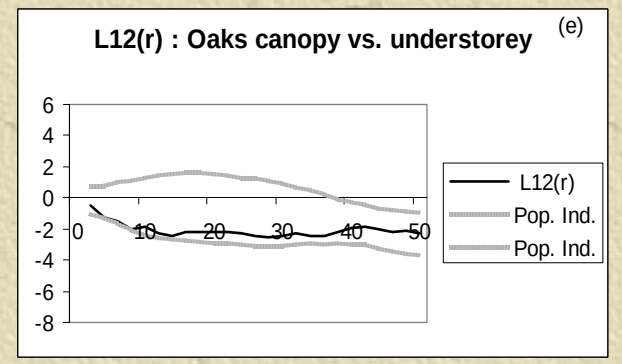
III.3 one example.



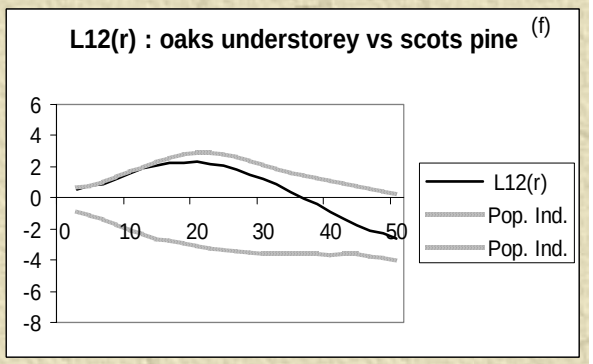








non significant repulsion

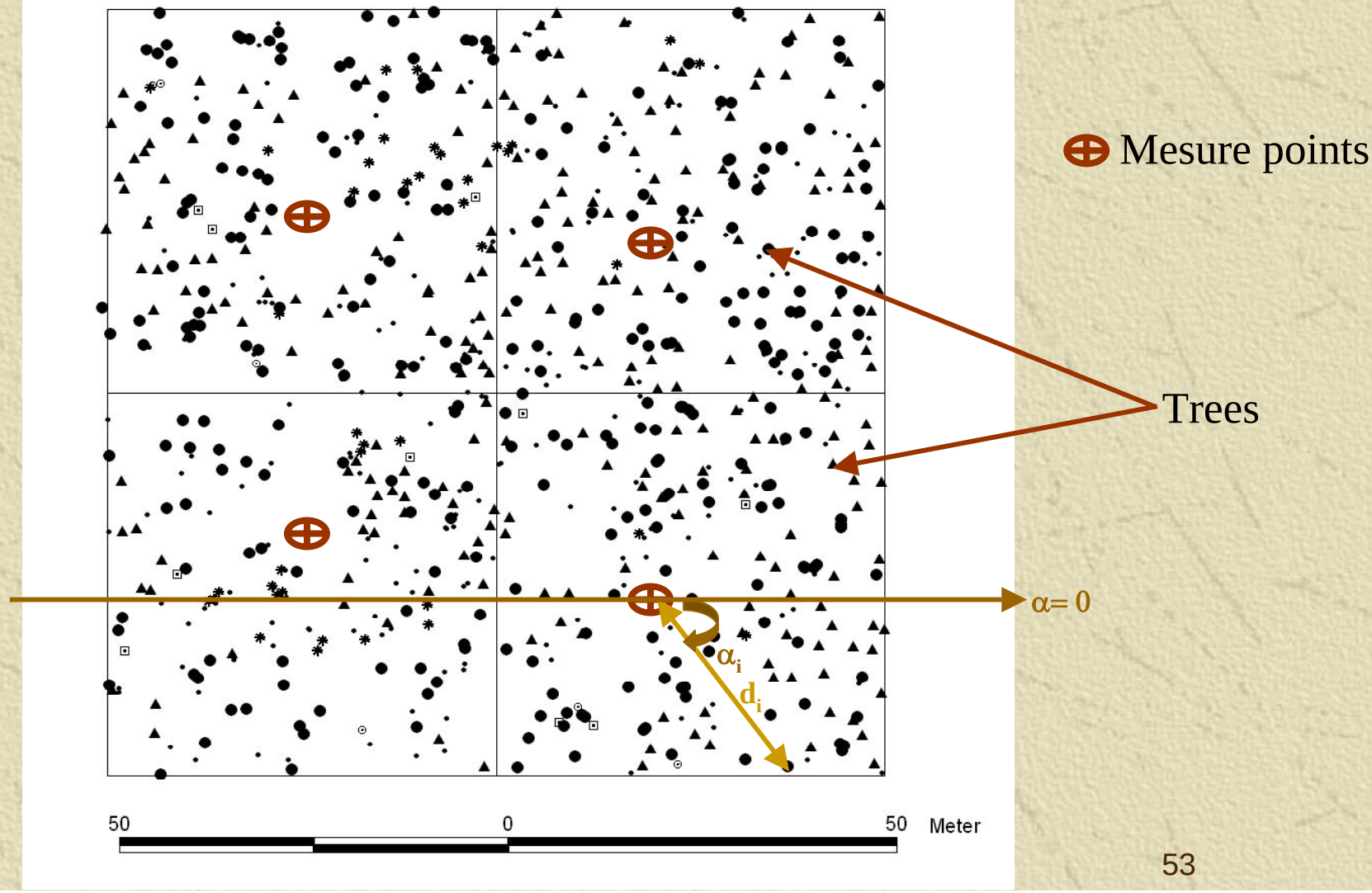


non significant attraction

Quelques références.

- La futaie irrégulière. Brice de Turckeim – Max Bruciamacchie. EDISUD. (2004).
- Modelling spatial patterns - Ripley, B. D. Journal of the Royal Statistical Society. (1977).
- Methods for analysing spatial processes of several types of points. Lotwick, H. W., and B. W. Silverman. Journal of the Royal Statistical Society (1982).
- Statistical Analysis of spatial point pattern. Diggle p.j. Academic press, New york. (1983).
- Simulating realistic spatial structure for forest stands: a mimetic point process. Goreaud F. et *al.* Interdisciplinary Spatial Statistics Workshop, Paris. (2004).

II.2 Data collection

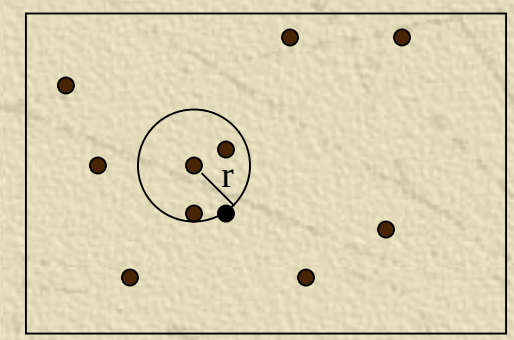


Méthodes : Analyse de la structure spatiale par la fonction L(r) (Besag in Ripley, 1977).

Soit un semis de points, de densité λ,

$$\lambda K(r) = E(Nb\ voisin\ d \leq r)$$

$$K(r) = \pi r^2$$

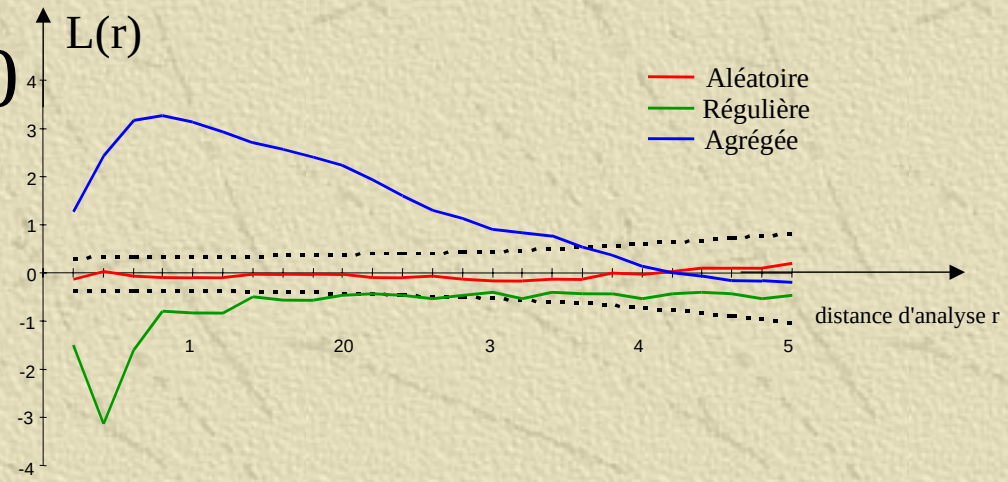


Zone d'étude

Méthodes : Analyse de la structure spatiale par la fonction L(r) (Besag in Ripley, 1977).

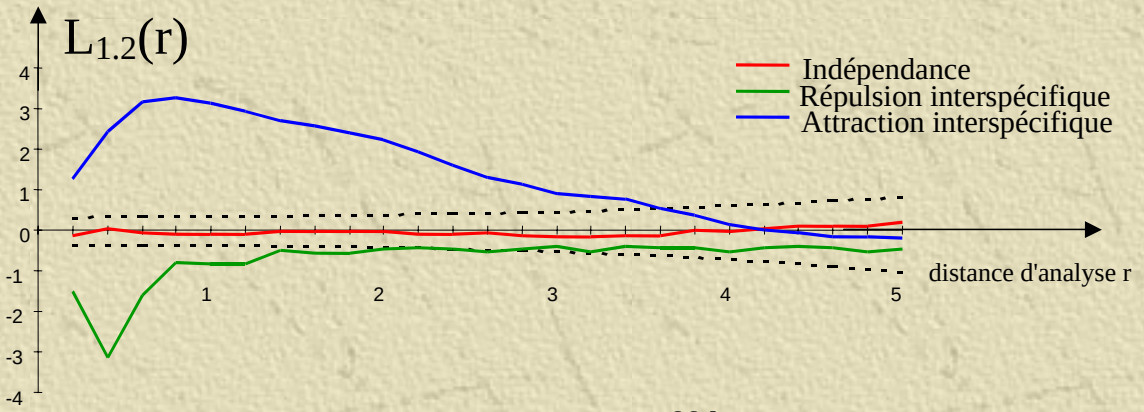
$L(r) = (K(r)/\pi)^{1/2} - r$

- Régulière, $L(r) < 0$
- Aléatoire, $L(r) = 0$
- Agrégée, $L(r) > 0$



Courbes de Ripley pour les 3 différentes distributions

Méthodes : Analyse de la structure de la structure du mélange par la fonction Intertype.



Courbes intertypes pour les 3 différentes distributions intertypes

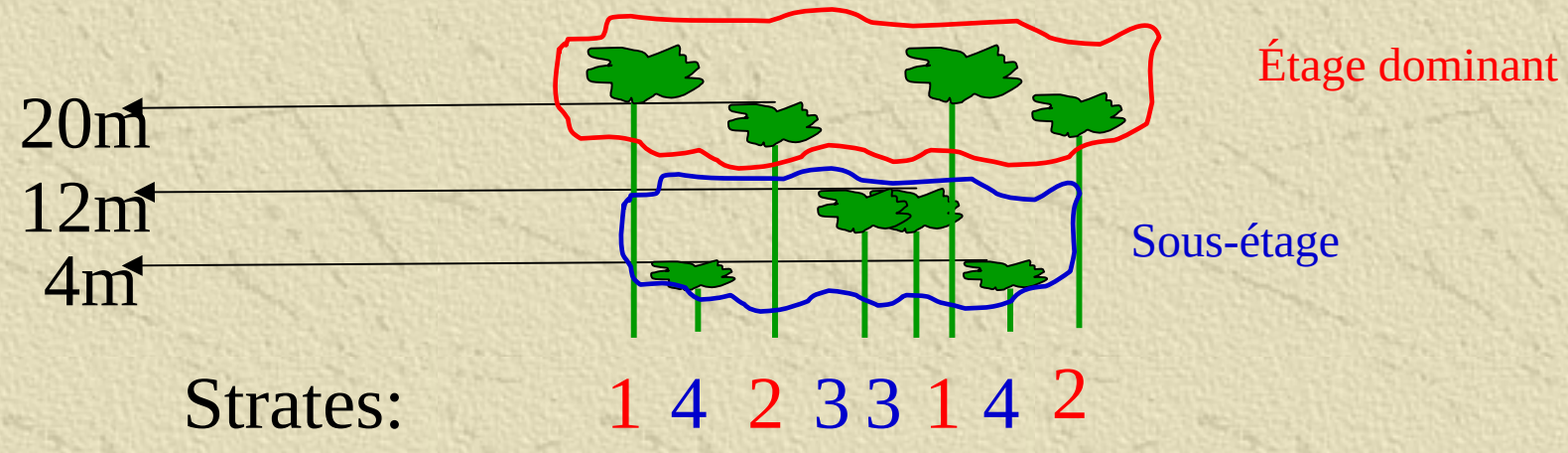
III.3 Questions.

- Notion de strate.

1. estimation à l'œil ;

- biaisée.

- pas toujours pertinente

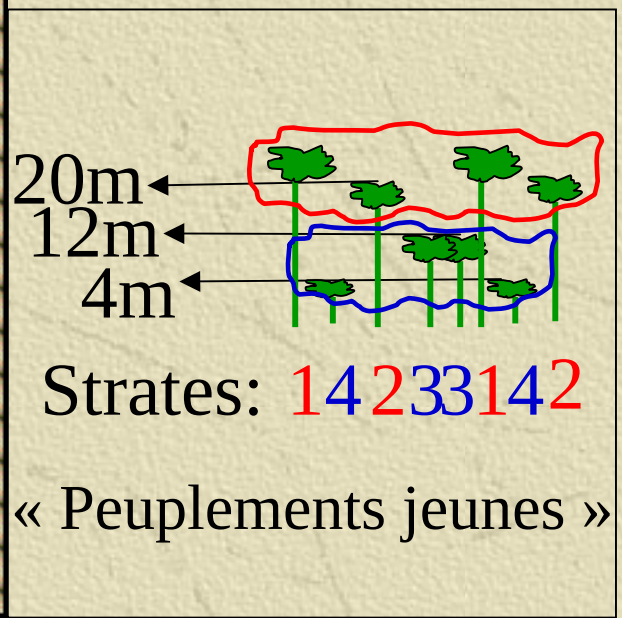


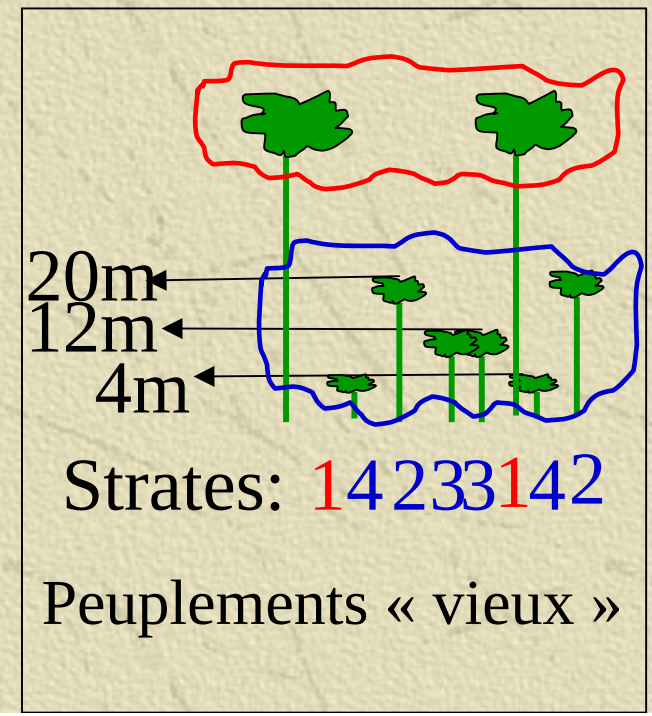
Perspectives

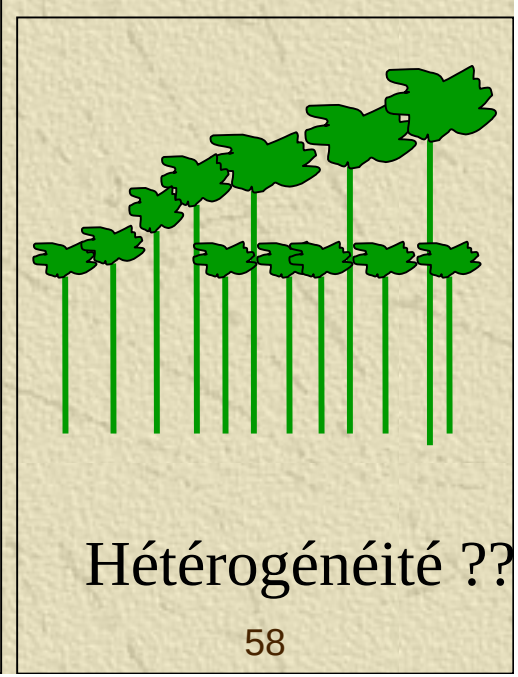
- Définition des sous-populations : retour sur le terrain

Sous-étage

Étage supérieur



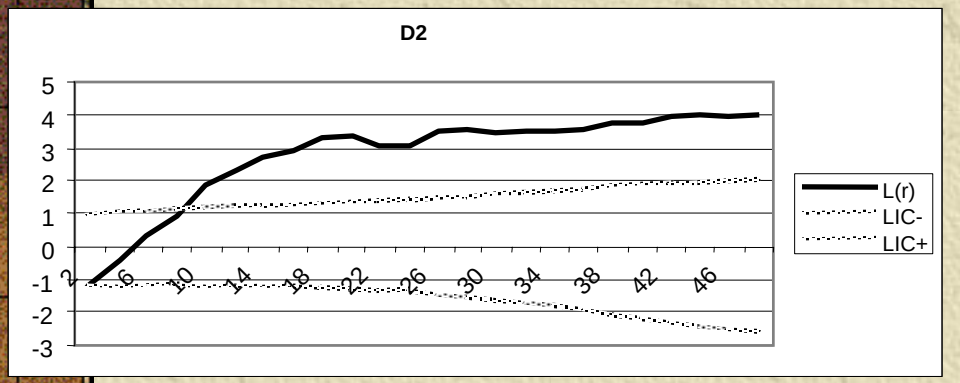


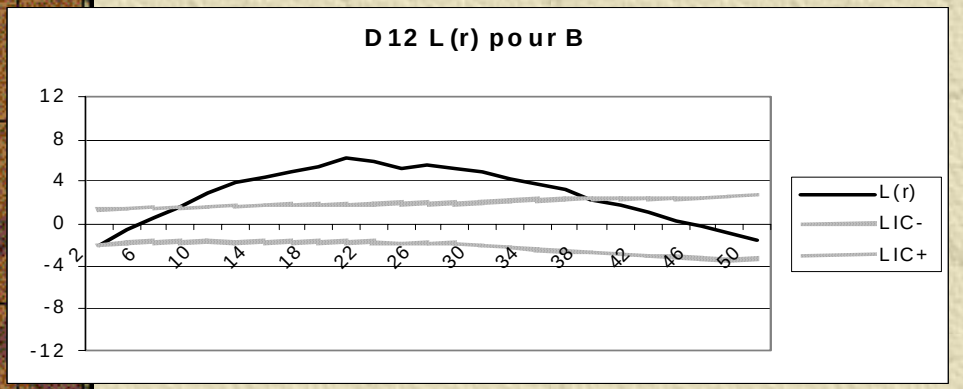


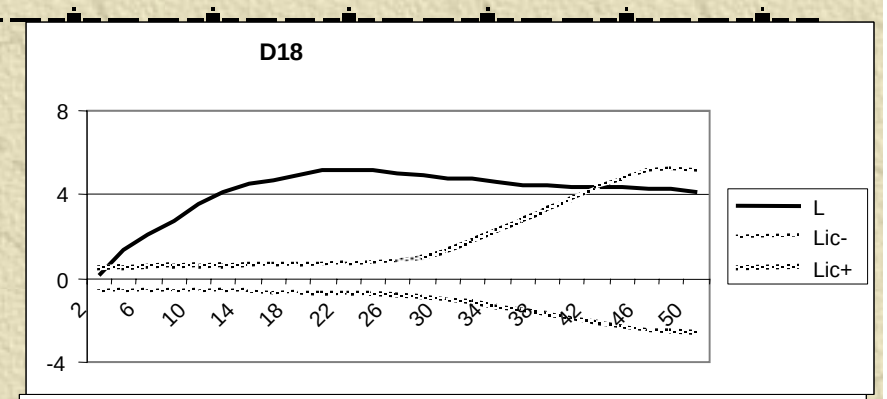
Simulation experte

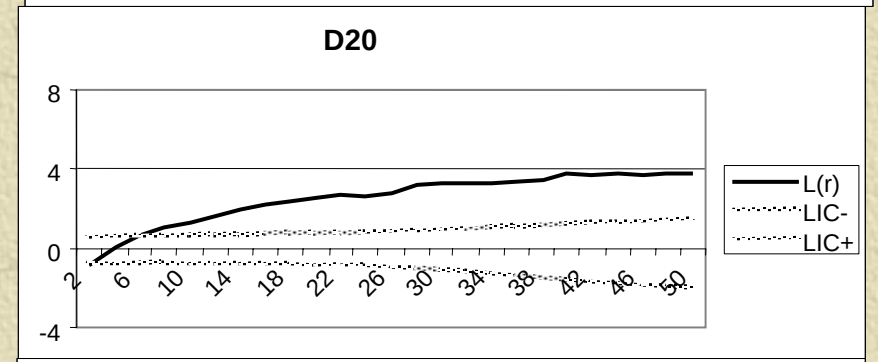
V.1 Le Type 3 : caractéristiques.

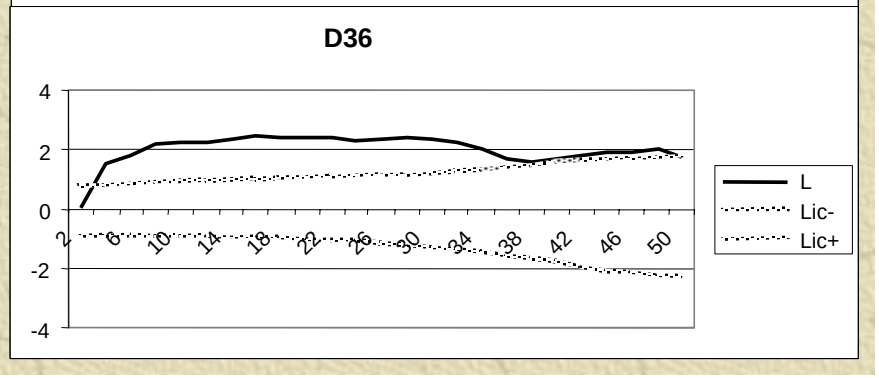
- L(r) pour les pins.







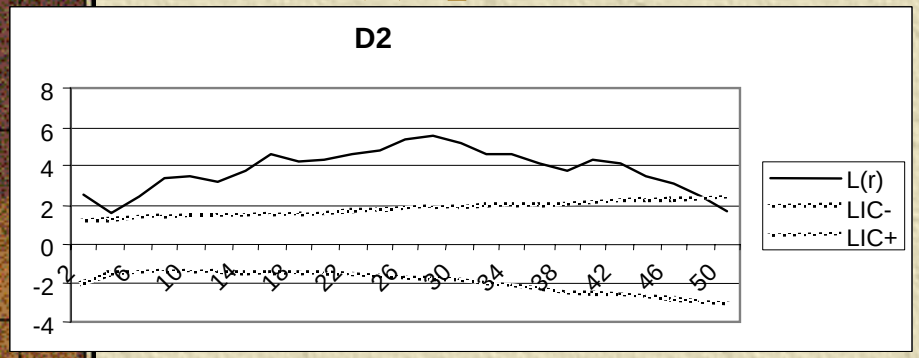


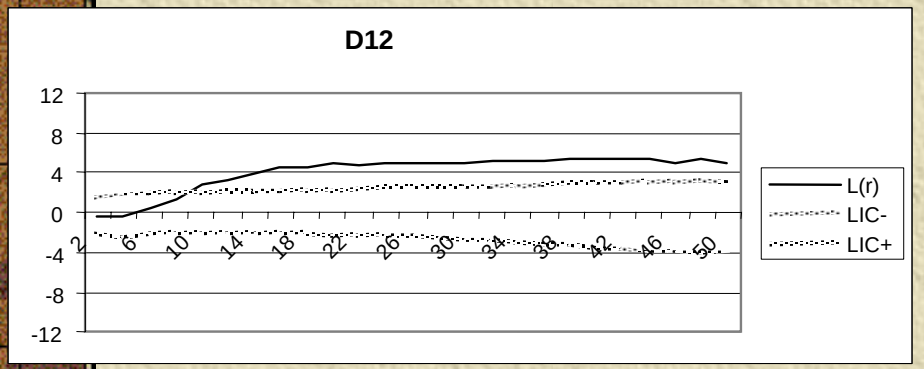


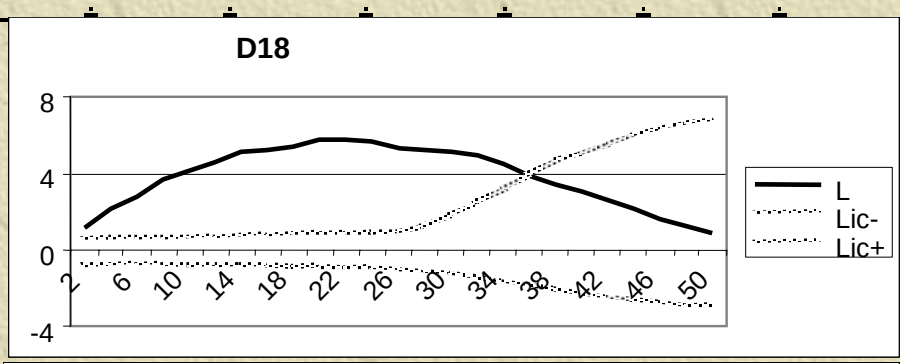
Simulation experte

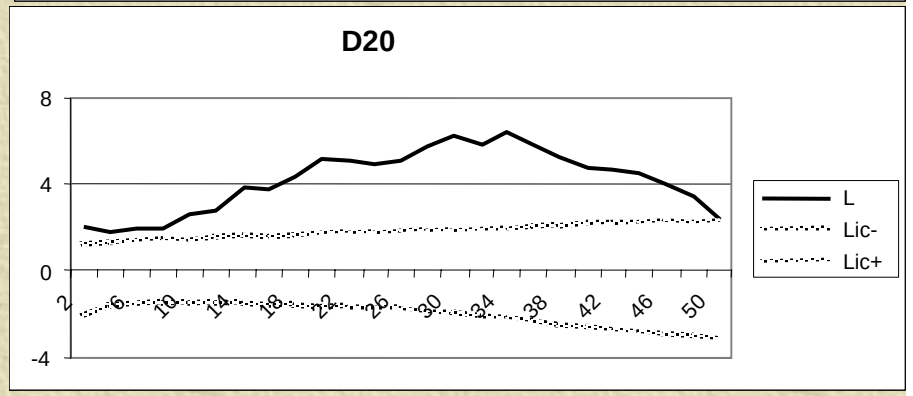
V.1 Le Type 3 : caractéristiques.

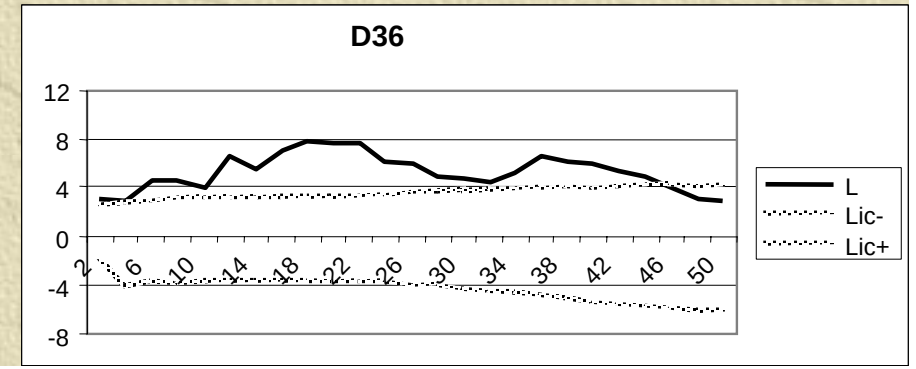
- L(r) pour les chênes











Simulation experte

V.1 Le Type 3 : caractéristiques.

$L_{12}(r)$