Rencontre LIRMM-ICAR / AMAP-I2P

One of my favourite bed test scene(extract from), M.J. June 2006-20XX

Représentation réaliste temps réel de la végétation dans des milieux naturels et anthropisés

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CIRAD-AMAP-I2P **GreenLab** **LIRMM-ICAR**

Sommaire

- Contexte, objectifs et positionnement
- Quelques résultats
- Thèmes exploratoires de recherche

From «Arbre, regards croisés» exhibition, Jardin du Luxembourg, Paris, M.J. June 2010

Contexte

La représentation tridimensionnelle de notre environnement est importante dans la communication et la planification de projets d'aménagement.

- AMAP: un labo référent pour la structure des plantes et espaces

- Des projets en cours (TAFER) et soumis (Valorhiz) pour visualiser des communautés sur des terrains en pente

- Un partenariat de recherche avec Bionatics SA qui distribue LandSim3D et un simulateur de plante issu d’Amap

Objectifs

Représenter (simuler et visualiser) des scènes naturelles ou anthropisées à l'échelle de la culture et du « petit paysage ».

Des challenges à relever:

C1. Naviguer dans des vues visuellement réalistes.

C2. Illustrer la variabilité:

- dans la population (nombreuses espèces)
- dans une espèce (croissance, aspect stochastiques, environnement…)

C3. La dynamique temporelle (croissance et phénologie)

C4. Des cas particuliers (petits organismes ou organismes fins)

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- ***Quelques résultats***
- Thèmes exploratoires de recherche

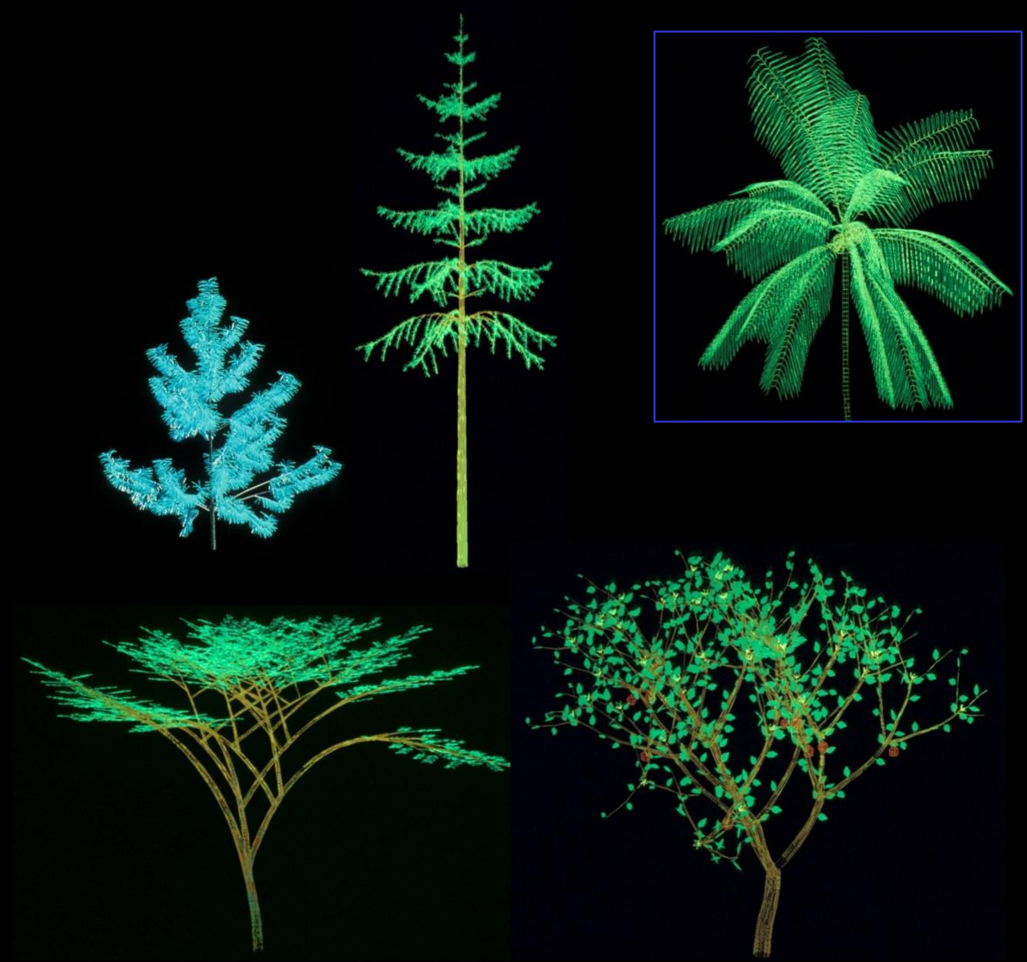
3D cephalometry rendering. CT scan: Dr. J. Treil, Clinique Pasteur, Toulouse. M.J. 1998

Plant structure and visualisation (early works)

- Objectives:
  - Define single plant visualisation approach for AMAP
  - Contribute to the definition of landscape design and rendering tools, and its valorization (mainly Engineering)

- Principles (Siggraph’88)
  - A plant is a list of components (generated in prefix order)
  - Geometry is defined within simulation at each internode position
  - Output builds a display list (without primitives): the Line Tree
  - Plant visualization is a post process
  - Landscape design and rendering are processed tree by tree without memory loads (read and render)

Plant structure and visualisation (early works)

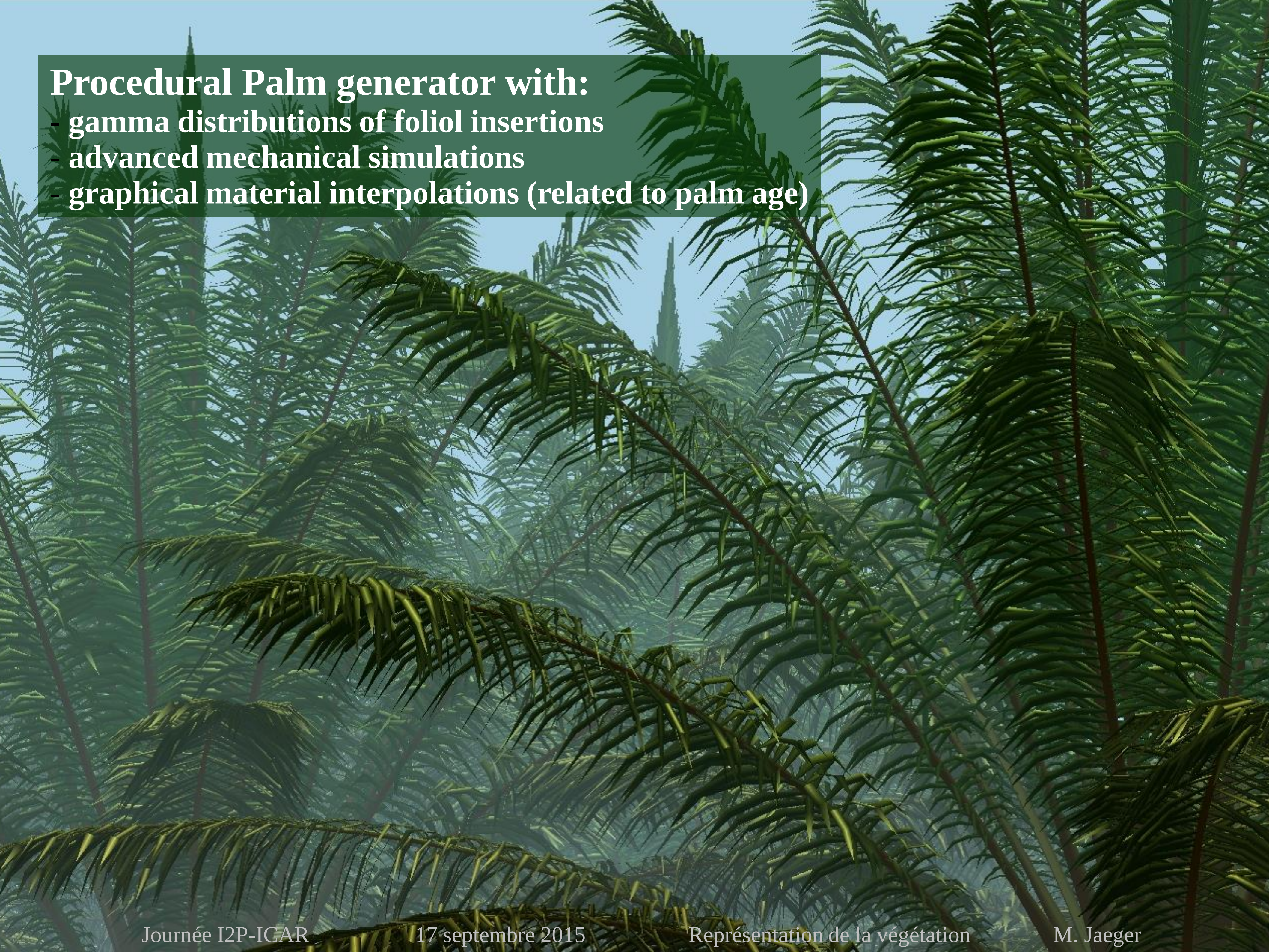


Early plant visualisations (1986-88)

Several procedural levels :
Rhizom, leaves, flowers

Procedural Palm generator with:

- gamma distributions of foliol insertions
- advanced mechanical simulations
- graphical material interpolations (related to palm age)



Une stratégie pour construire des actions de R&D

- From structure to function

From organs (static) → to Landscapes (dynamic)

Explicit geometry (polygons)

Points / lines (« surfels »)

Production Representation

Production driven Visualisation

Polygon Decimation
Dynamic Meshing

Geometry decimation
GPU advanced Use

Converting Biomass to Geometry

Building Geometry on request

Une stratégie pour construire des actions de R&D

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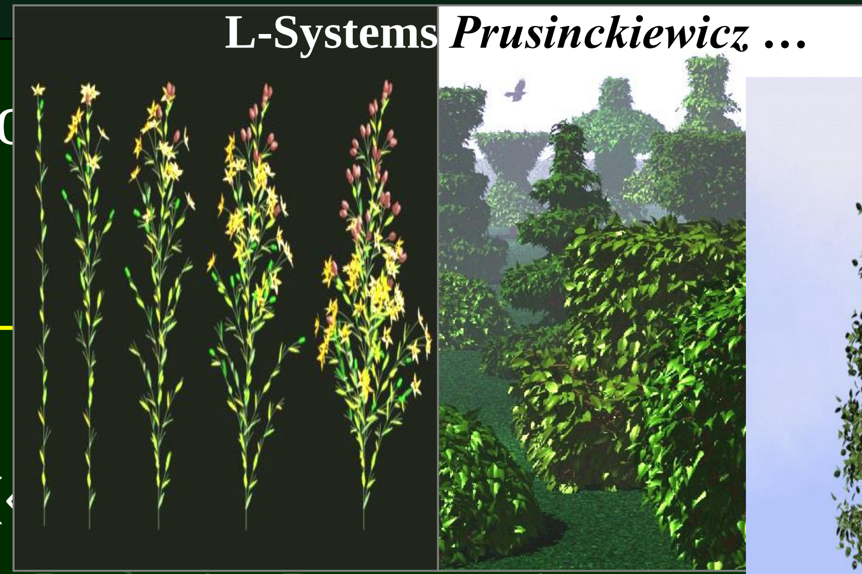
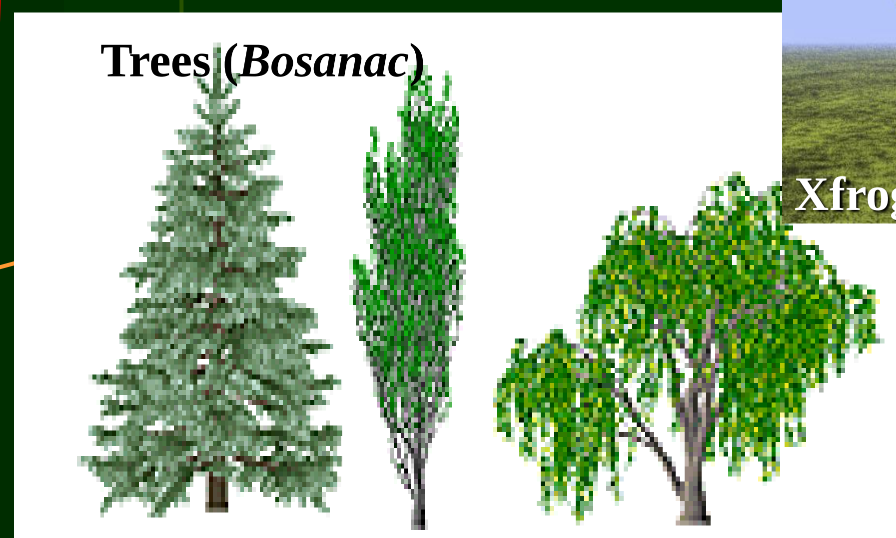
Points / lines (

Classical, many contributions



Rule based plant models generate usually polygons



Polygon Decimation
Dynamic Meshing

Geometry decimation
GPU advanced Use

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Une stratégie pour construire des actions de R&D

- From structure to functi

Comparative study of Ismael Garcia Fernandez (GGG, Uni. Girona, Spain)

Category	Algorithm	branches	leaves	view dependent LOD	animation	dynamic lighting	instancing	quality	performance
Polygonal	Fractal Plants and Trees [Opp86]	✓			✓	✓	✓	○	●
	Multiresolution Botanical Scenes [MFATC97]	✓	✓	✓		✓		◐	●
	Single Polygonal Mesh [LVF+01]	✓				✓		●	○
	Multiresolution Foliage [RCRB03]	✓		✓		✓		○	●
	Procedural Multiresolution [LCV03]		✓	✓		✓	✓	◐	●
Point Based	Structured Particle Systems [RB85]	✓	✓			✓		○	○
	Rendering of Realistic Trees [WP95]	✓	✓	✓			✓	◐	◐
	Interactive Plant Ecosystem [DCSD02]	✓	✓	✓			✓	●	○
	Point-based trees [GMN05]							◐	●
Image Based	Precomputed Z-Buffer Views [MO95]	✓	✓			✓	✓	◐	◐
	Hierarchical IBR [MDK99]	✓	✓	✓			✓	◐	○
	Shading and Shadowing [MN98]	✓	✓	✓		✓		●	○
	Slicing and Blending [Jak00]		✓				✓	○	●
	Image-Based Foliage Rendering [LCV04]		✓	✓			✓	◐	◐
	Volumetric forest scenes [DN04]	✓	✓	✓		✓		◐	●
	Volumetric reconstruction of trees [RMMD04]	✓	✓	✓				◐	○
	Extreme simplification for forests [FUM05]	✓	✓	✓		✓	✓	◐	●
	Landscapes billboard clouds [BCOJD05]	✓		✓		✓		◐	●
	Leaf Cluster Impostors for Trees [GSSK05]		✓	✓		✓	✓	◐	●
	Multi-layered Indirect Tex. Trees [GPSSK07]		✓	✓		✓	✓	●	●

From organs (static)

Explicit geometry (polygons)

Points / lines (

Classical, many contributions

Polygon Decimation
Dynamic Meshing

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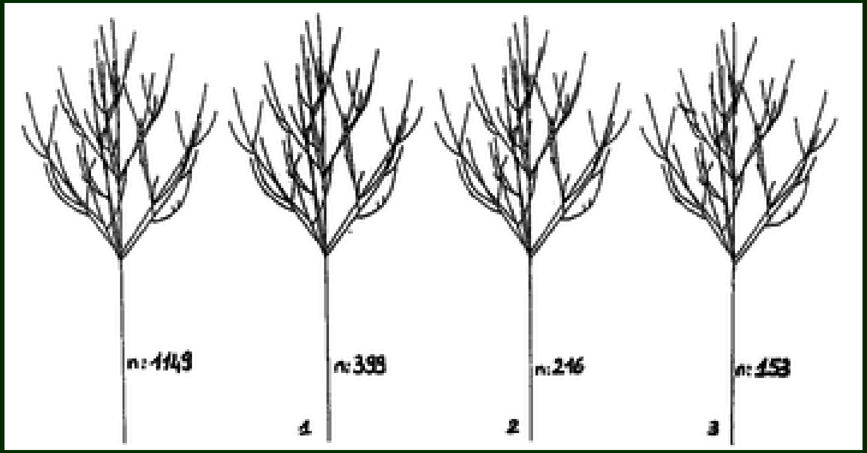
GPU advanced Use

Modèles multi-résolution

Bois: fusion de noeuds, branches décrites par équations et génération du maillage au rendu à la volée



Collaborations avec le LIAMA:
Zhang Xiaopeng team
CGW 2010, submission to CGF 2015

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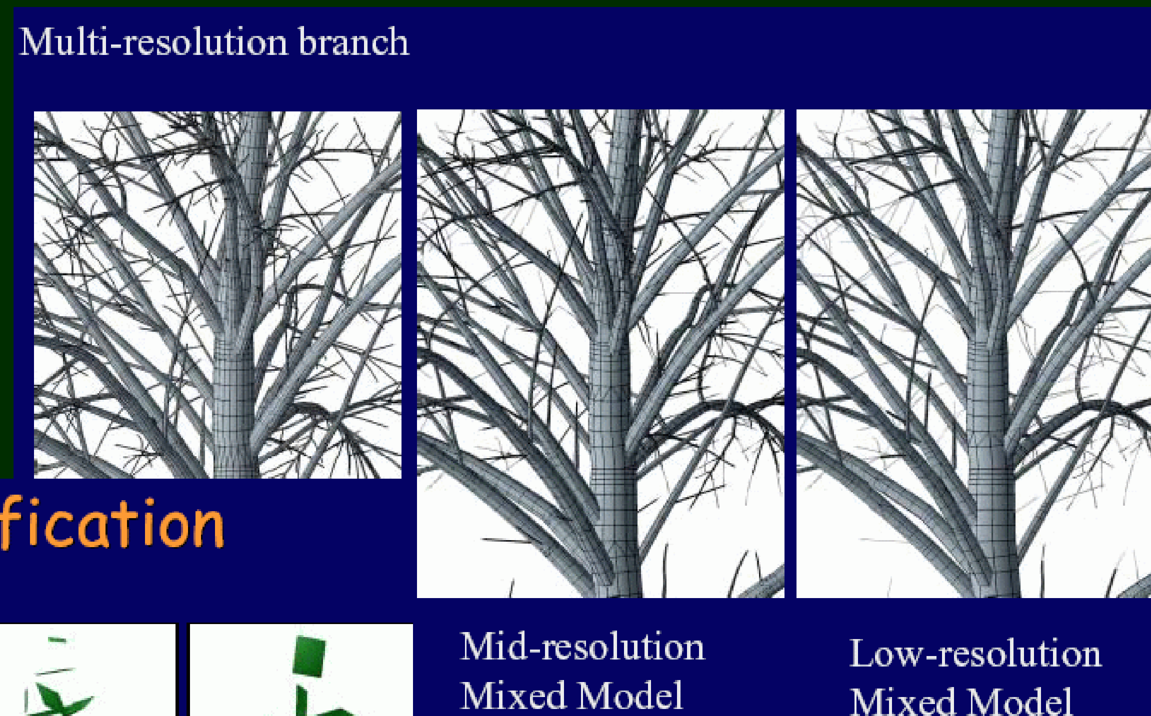
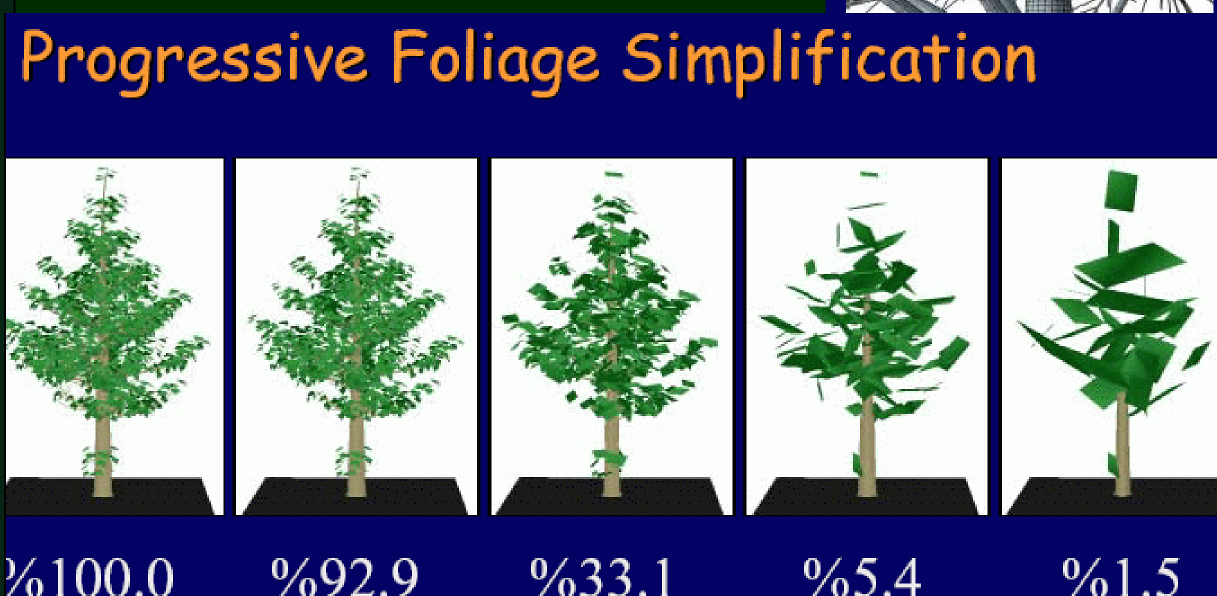
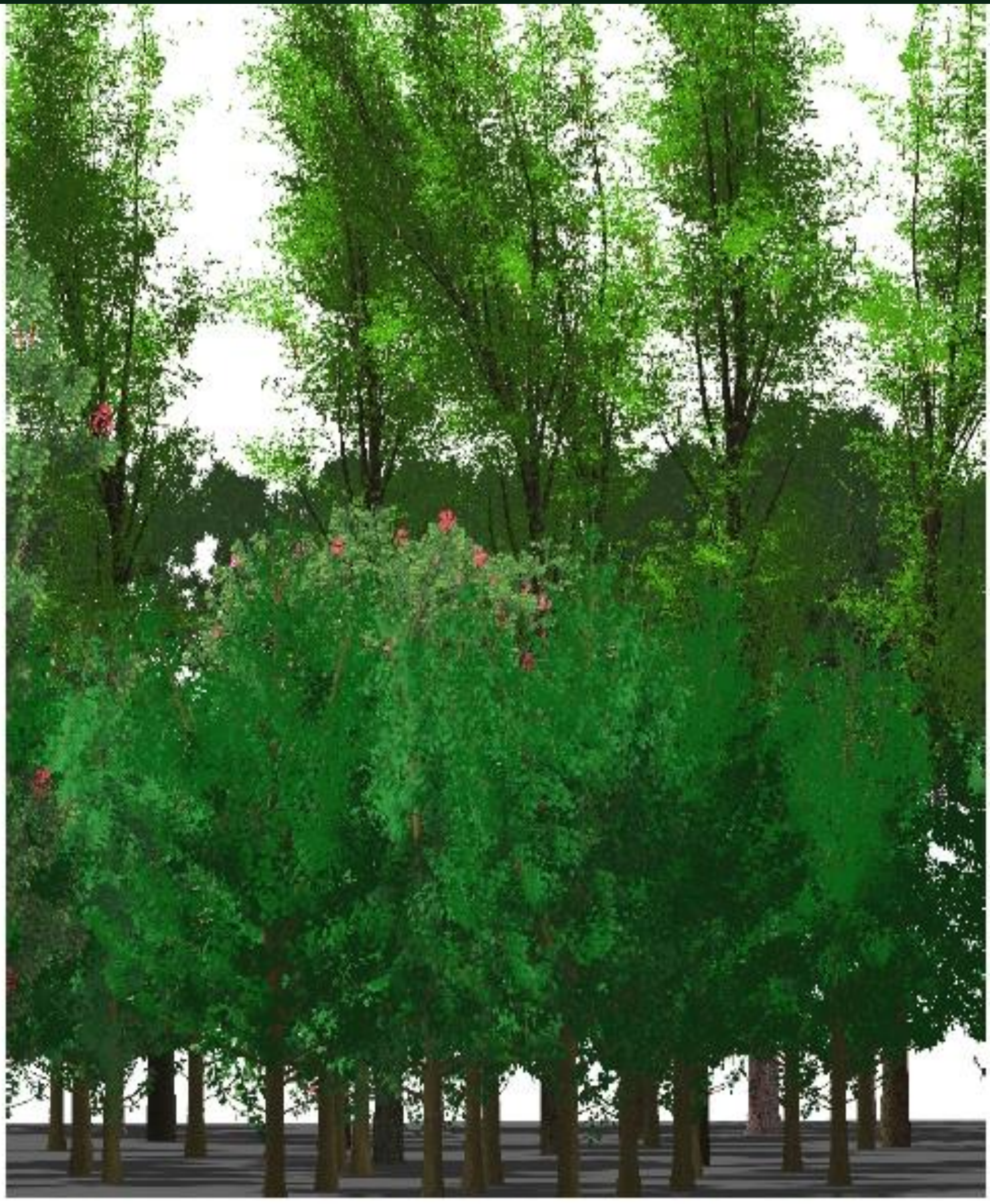




Feuilles: fusion hiérarchique

Scènes temps réel. Exemples



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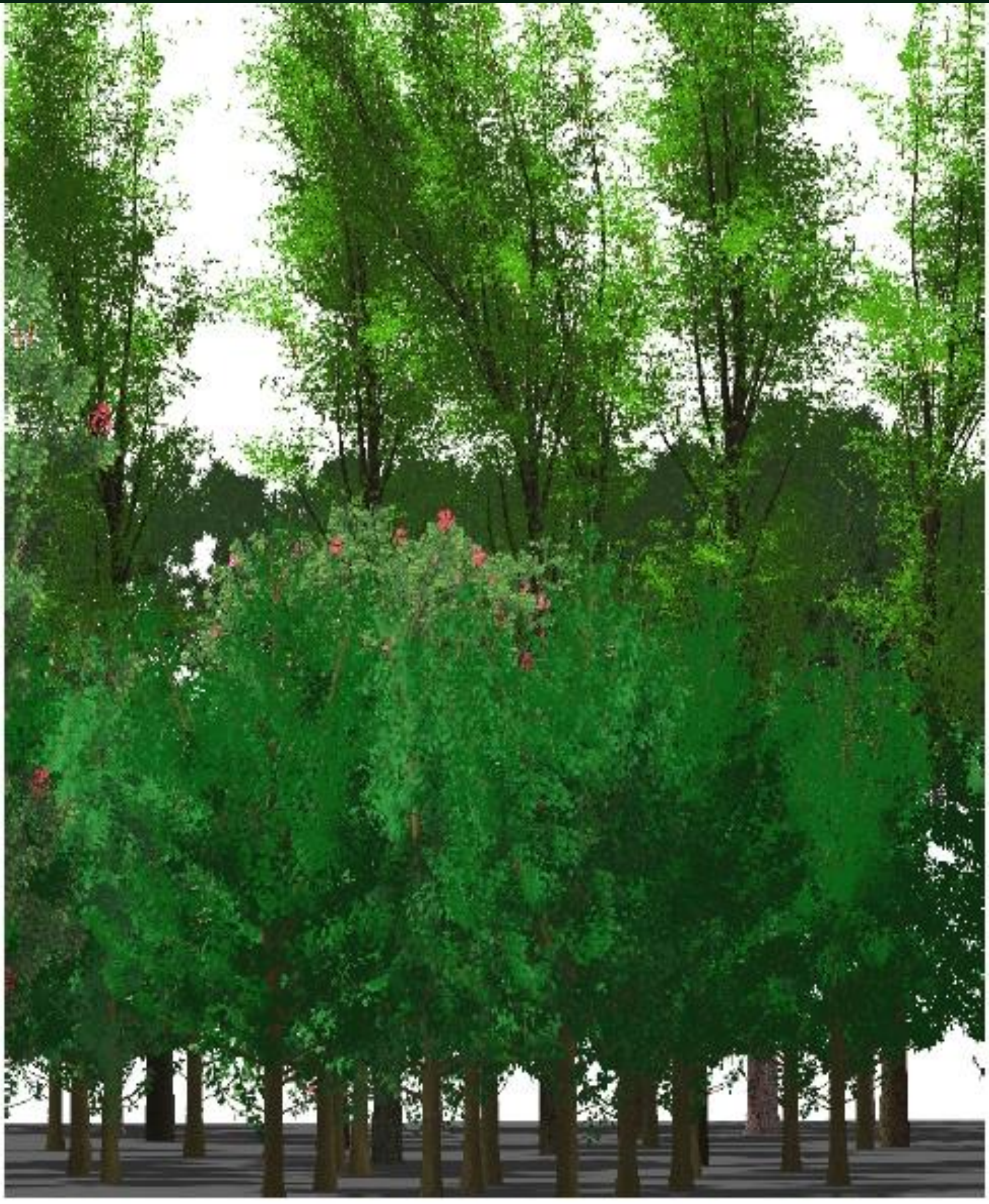


Vers le paysage fonctionnel (prototypes)

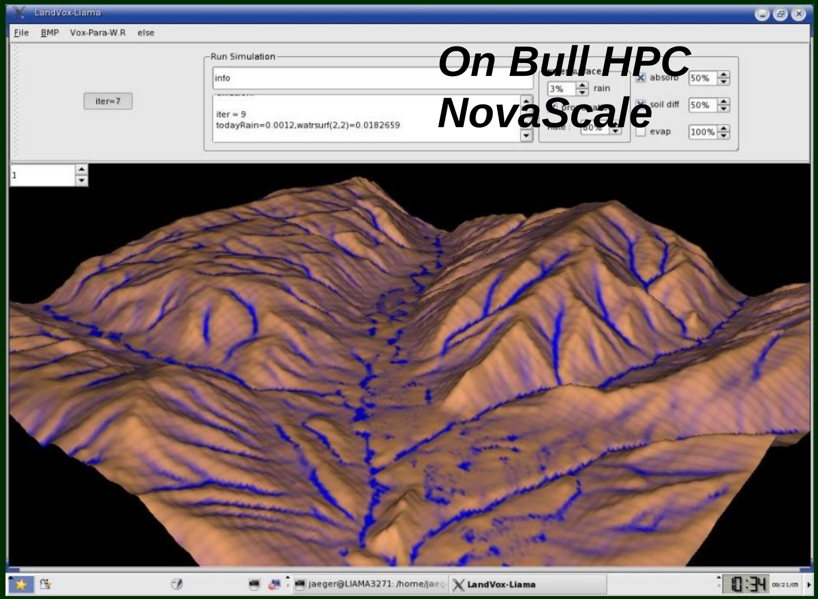
Objective:

Simulate plant/environment feedback from water competition in soil voxels.

Principle: simulate a simple water cycle on a daily basis with 6 processes:

- Rain
- Run-Off and absorption
- Diffusion
- Plant growth
- Evaporation

  - *In a voxel space (Ned Green inspired)*
  - *Simple plant model (simple leaf)*
  - *Fluxes: diffusion on voxel neighbours*



Phd Mei Xing, LIAMA

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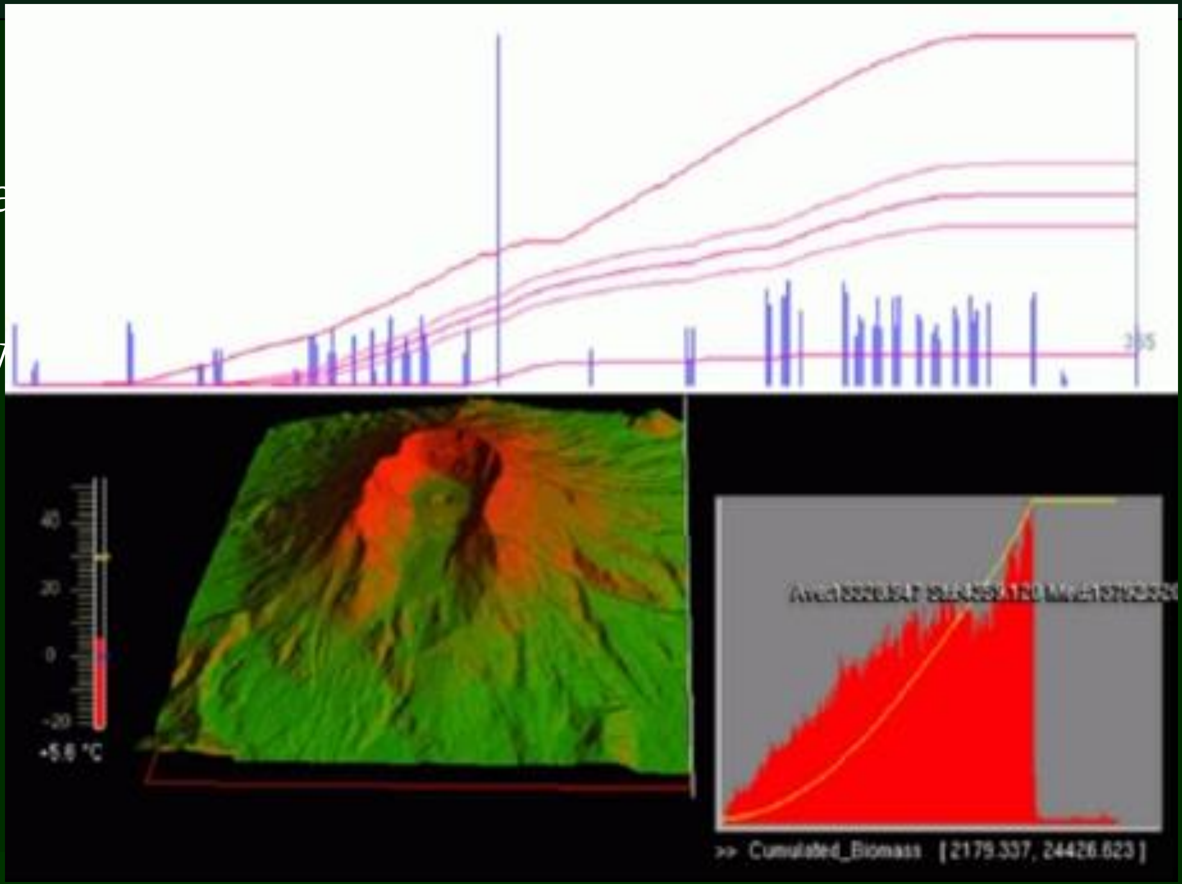
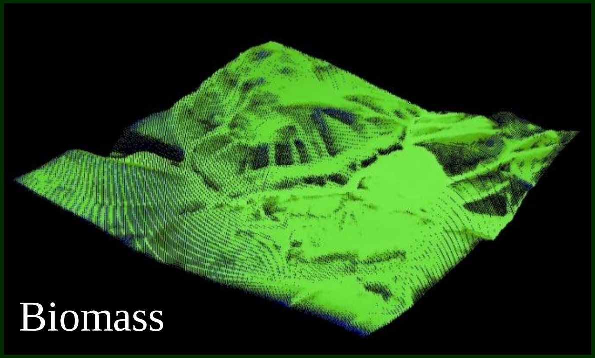


Proto 2. Complete plant model (no structure)
Implement “classical models”
“Force” models to run on a day time scale
Use a classical layer approach

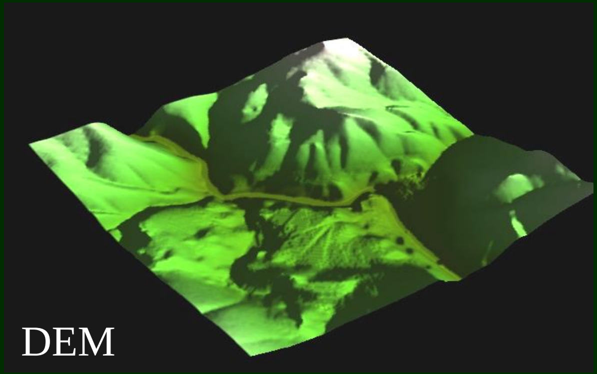
Phd Vincent le Chevalier, ECP
JCST, 2009

Functional Landscape visualisation (daily layers)

Soil water content

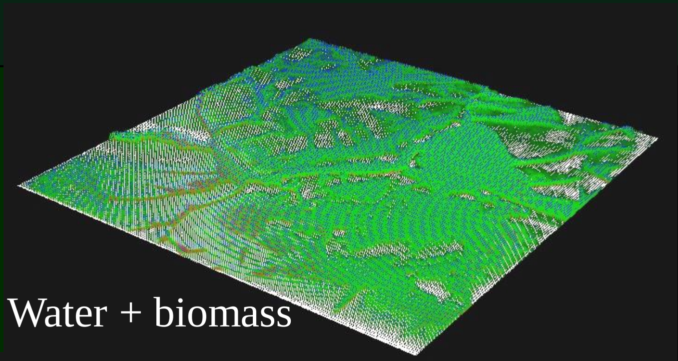


Biomass

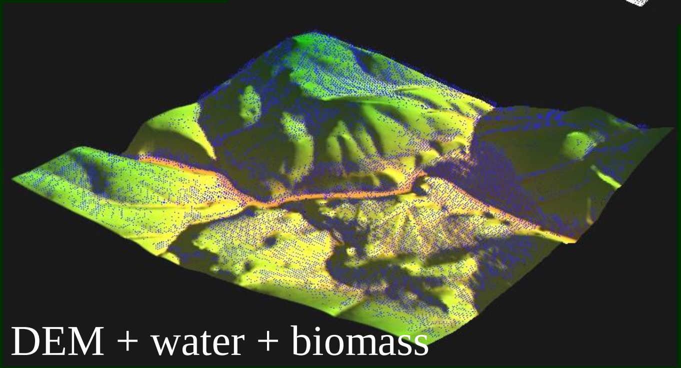


DEM

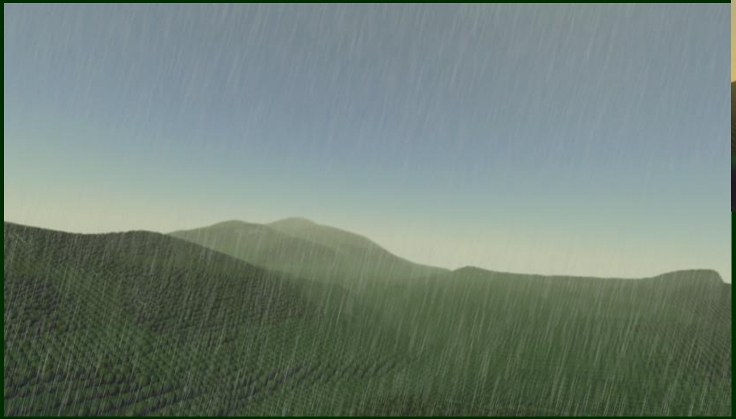
Mix and/or Combine

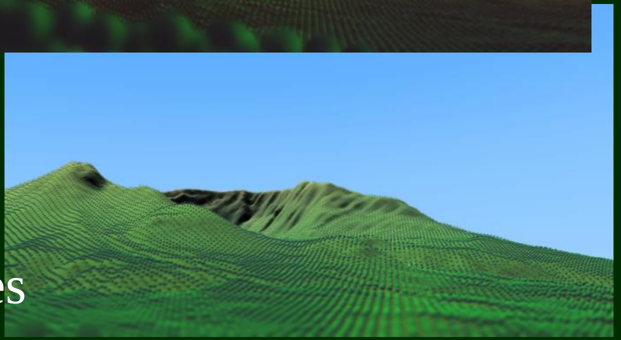


Water + biomass



DEM + water + biomass





Realistic views with post-processes

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demo live Amap Maya Plug-in, Maya Booth, Siggraph'00, L.A. USA, M.J. August 2000

3 axes pour un objectif unique

- One single objective:

  Simulated vegetation visualisation at crop, stand, landscape scale in agronomy, forestry and ecology applications.

  => Reflecting the ecosystem and its heterogeneities (plasticity)

- Key points:

  Assume continuity and ascendant compatibility

  Keep the strategic track : structure → function

  Center the research to a unique object: the single plant structure and function representation but applying it on a wide range of scales from individual to landscape and exploring its plasticity towards environment

- In one word: build the forest (with realism) from a single tree
- Ideas and tests: to be developed (Master, PhDs, …)

Explorer l'architecture passée

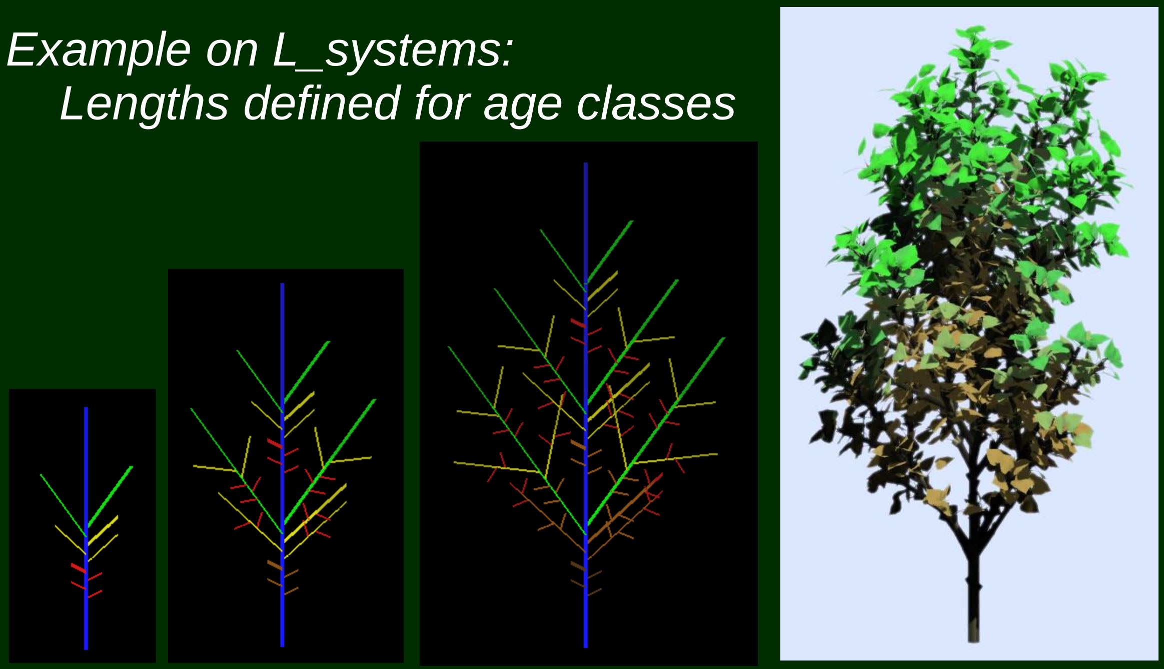
Exploring a tree graph built at final age stage with constraints on the birth date compared to reconstruction age.

Axis/Leaf self pruning : ignoring nodes born after the specified date

Node length is stable (immediate expansion).

Diameters are interpolated (function of current age and diameter at final age)

Example on L_systems:
Lengths defined for age classes



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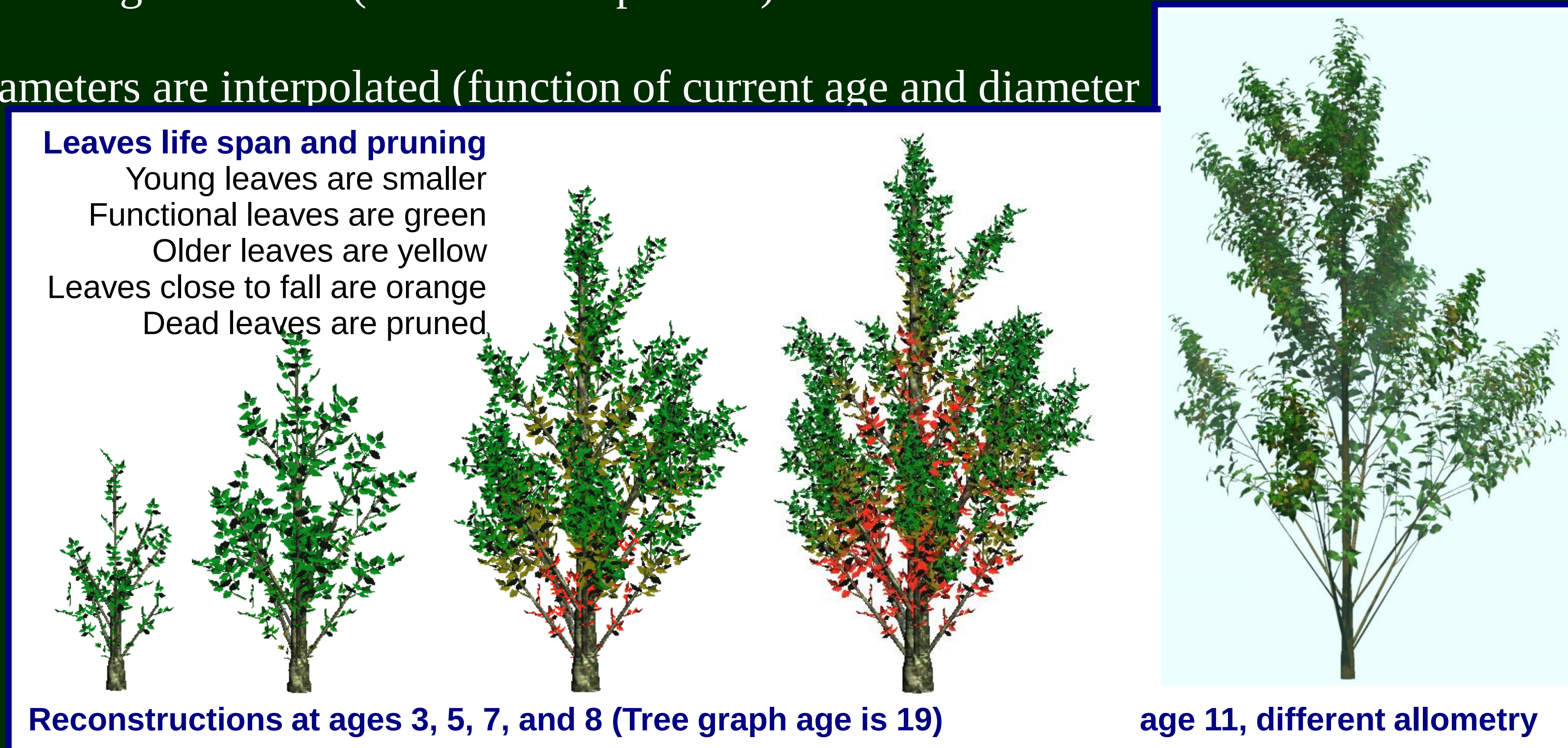

Scène de 200 plantes, 14 distinctes obtenue de 2 simulations.

Exemple. A small natural scene build from a tree position list and two tree graphs. (200 trees, 14 different reconstructed plants, 2 tree graphs)

Scène de 200 plantes, 14 distinctes obtenue de 2 simulations.

Exemple. A small natural scene build from a tree position list and two tree graphs. (200 trees, 14 different reconstructed plants, 2 tree graphs)

	Tree Graph		Single Tree Reconstruction			Full growth Sequence
	Graph size	Nodes	Age and Final age	Components	Line tree size	Sequence size
Single L_system	2.2 Kb	252	7 on 10	5570	251 Kb	2.5 Mb
Single Functional	16.7 Kb	2006	7 on 19	3287	156 Kb	23.8 Mb
Single Functional	16.7 Kb	2006	11 on 19	10049	474 Kb	23.8 Mb
Forest Scene	18.9 Kb + 40 Kb	2258	mixture	> 3 000 000	> 0.3 Gb	

Memory costs (ie transfer costs) table

Générer la géométrie depuis le fonctionnement

- Objective:

  Generate plant geometry from the plant production

  and organs numbering

- Principals:

  Focus on leaf organs to model the crown

  Define the Sphere equivalence from leaf biomass volume

  Apply the representations recursively using sub-structures

  Introduce constraints related to growth dynamics

  Have a bottom up approach (from simple cases to complex)

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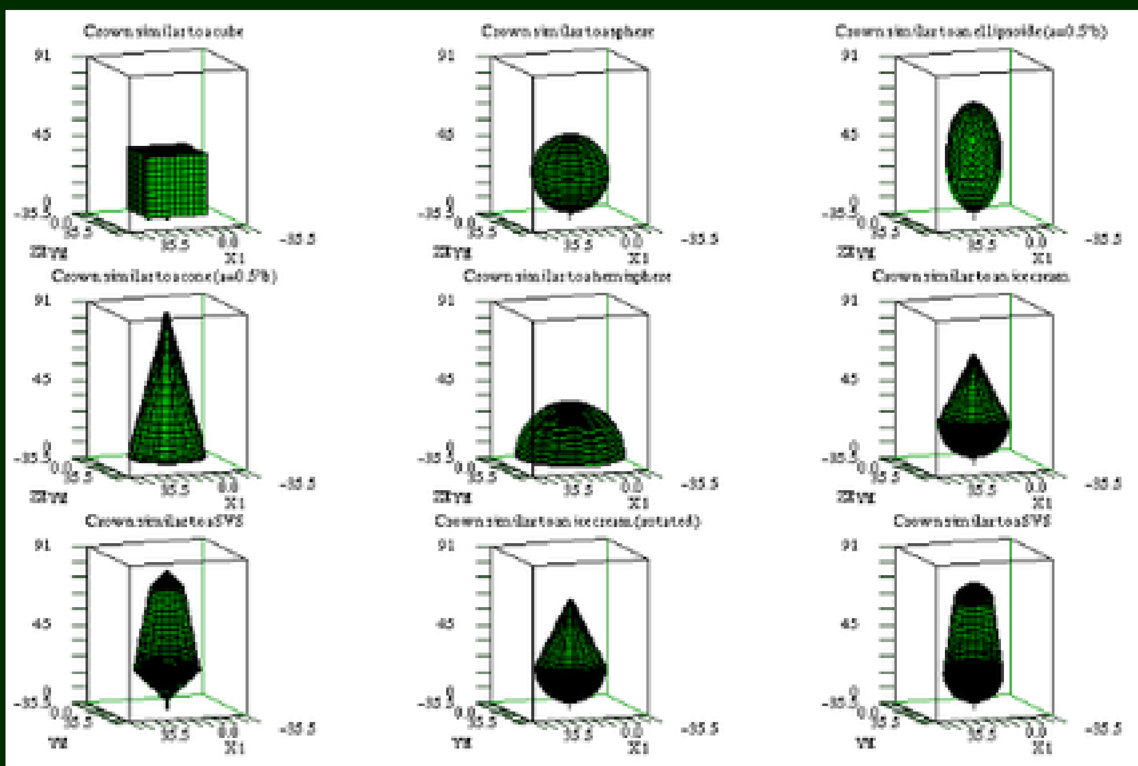

Sets of volume equivalent crown shapes (Mst CA Douet)

rown

leaf biomass volume

ly using sub-structures

vth dynamics

mple cases to complex)

Générer la géométrie depuis le fonctionnement

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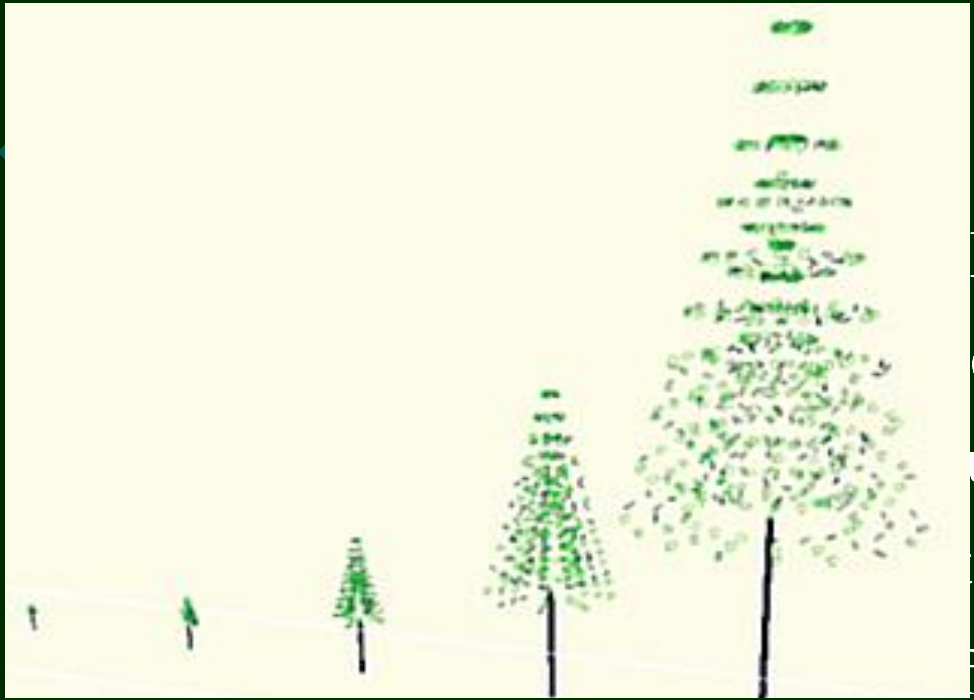

Crown definition under leaf dynamic position constraint

l the crown

e from leaf biomass volume

ursively using sub-structures

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from simple cases to complex)

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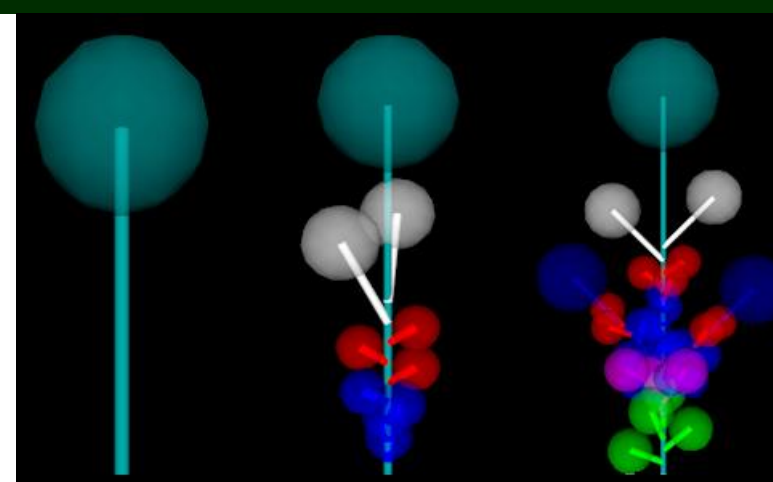


Strutural view, functional views with various orders and physiological ages (Mst M. Luong)

La géométrie fonctionnelle. Points difficiles

A geometrical constrained design problem: not easy, discouraging students

Constraints expressions are difficult (dynamic).

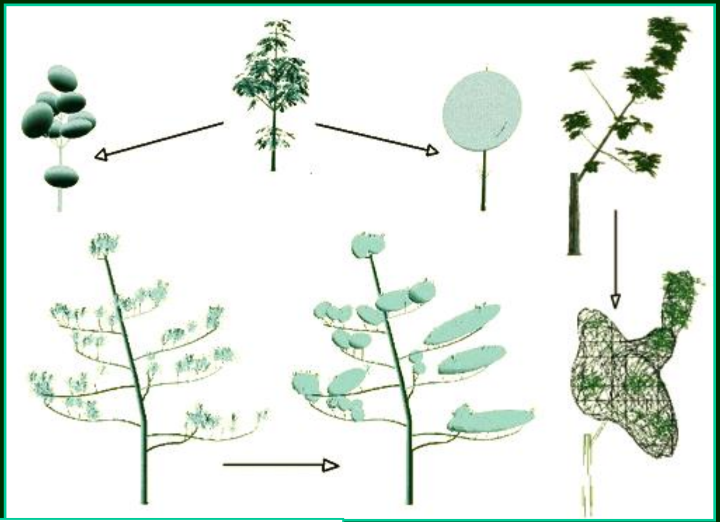
How can we insure LoD capabilities related to sub-structure levels ?

Will it be possible to assume smooth transition between functional representations and structural ones ?

Dispersion analysis helps.

To test with

sub-structures



E-skeletons on leaf positions (PhD F. Banegas)

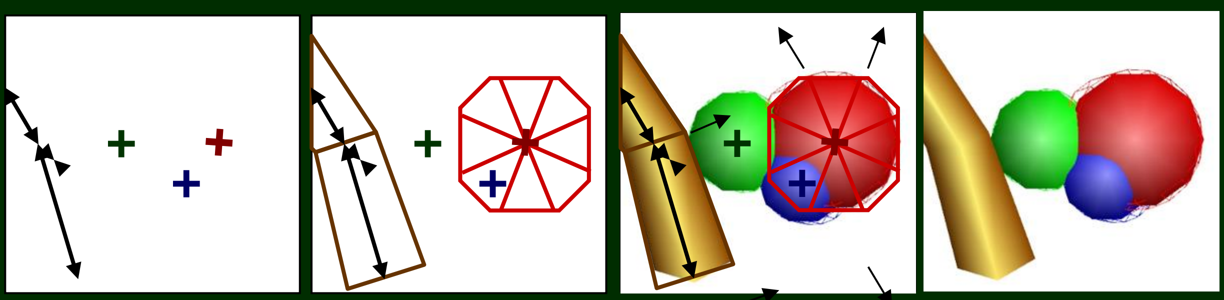
Leaf dispersion versus physiological age

La GPU !!!

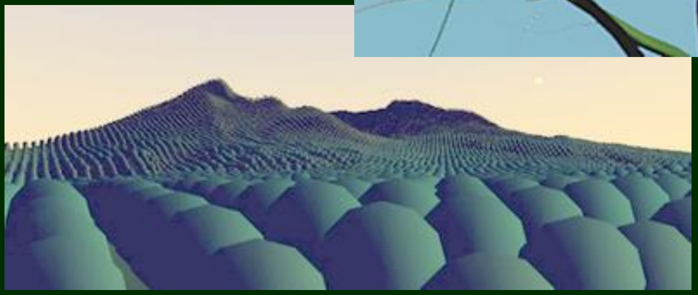
- Significant performances gains from GPU use

Geometry generation from nodes and radii

tests already hold by BJFU on axis and crowns



CPU, 3D   GPU, 2D   GPU 2D 1/2



Substructure

Easy in theory, but is instantiation useful if geometry is generated on the fly ?

LoD capabilities

Easy in geometry generation more benefits if higher levels are considered

Encore de la GPU…

- CPU simulates tree graph classes… and GPU builds the forest

GPU's work:

- Procedural seeding (eye depending)
- Competition class definition (results from seeding)
- For each visible plant: Reconstruction from the tree graph
  - From appropriate competition class
  - With appropriate LoD level: reconstruction axis per axis, from trunk
  - Switches or not to functional representation

Difficult points:

Lot's of engineering

Procedural models or data sets (texture, colors, bending, …) ?

Do we offer a real contribution ? (lots of teams on GPU)

Les petites plantes…

Une variabilité temporelle

phénologie (floraison)

Des structures fines et nombreuses

De nombreux individus (différents) nécessaires pour une petite surface

Une difficulté à mettre en œuvre le multi-échelle

Les petites plantes…

Une variabilité tempo

phénologie (floraiso

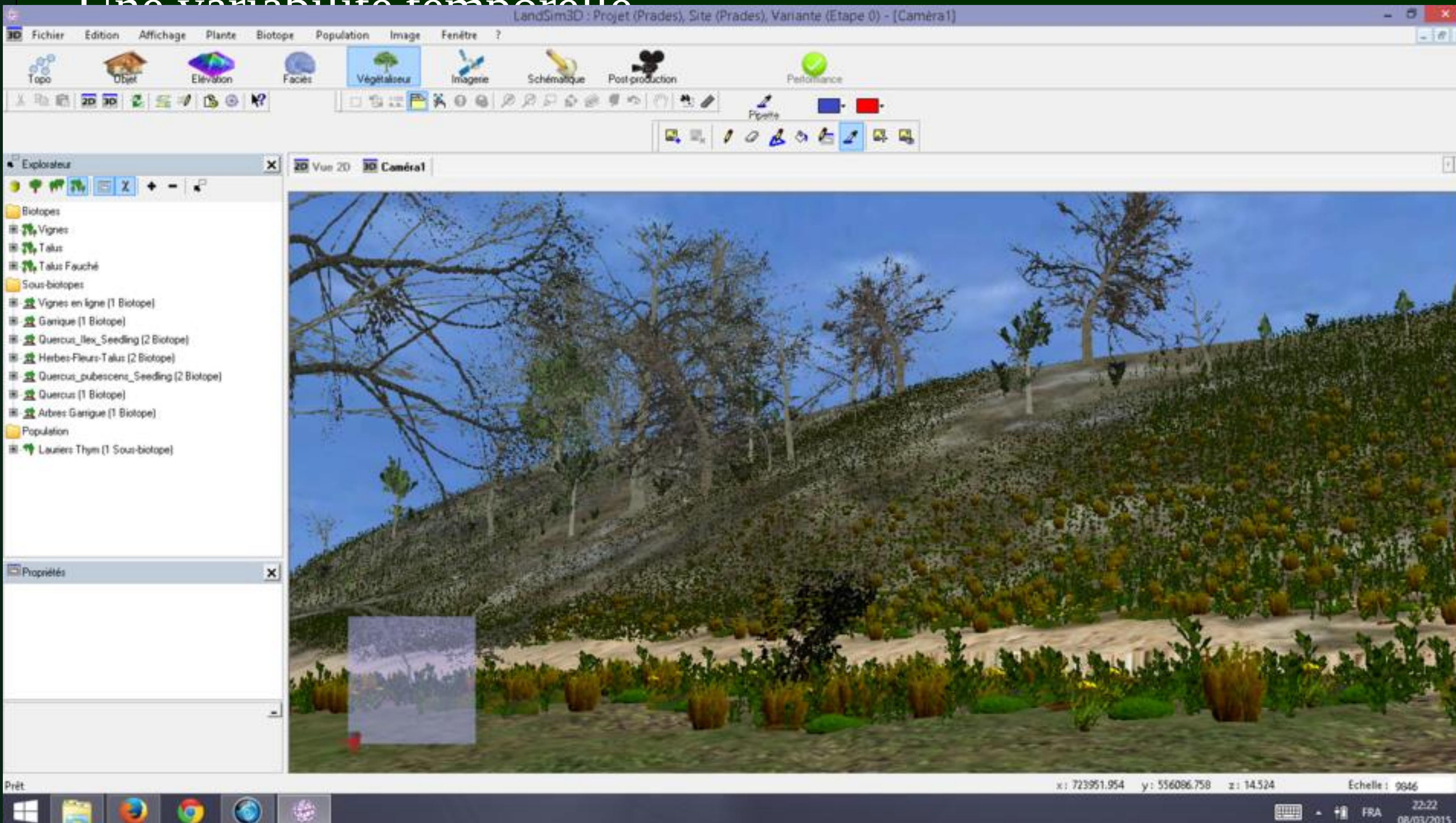
Des structures fines et

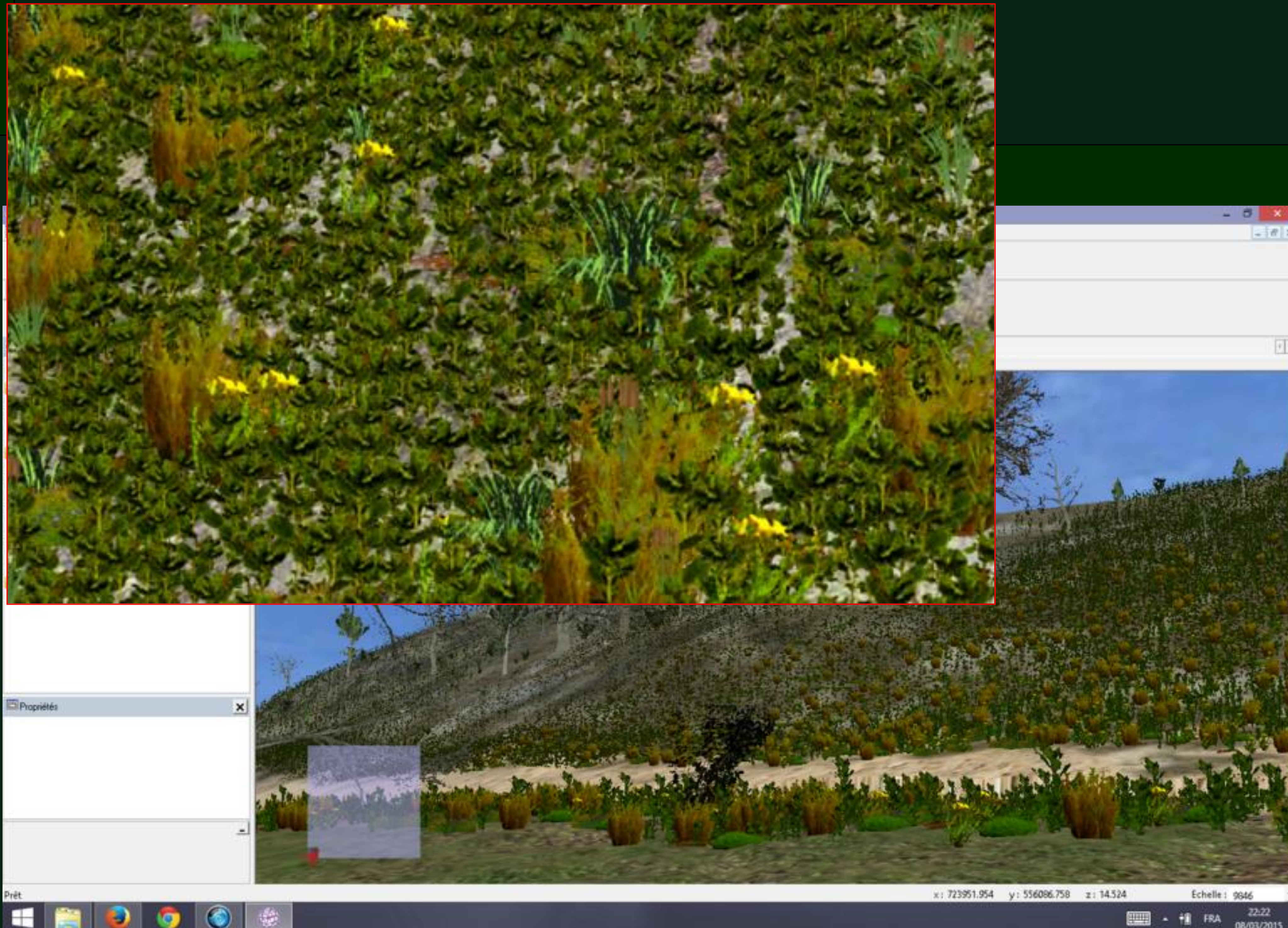
De nombreux individu
surface

Une difficulté à mettre

Les petites plantes…

Une variabilité temporelle




Propriétés
Prêt
x : 723951.954
y : 556086.758
z : 14.524
Echelle : 9846
FRA
22:22
08/03/2015

Chesnut Tree at sunset, M.J. 1989