

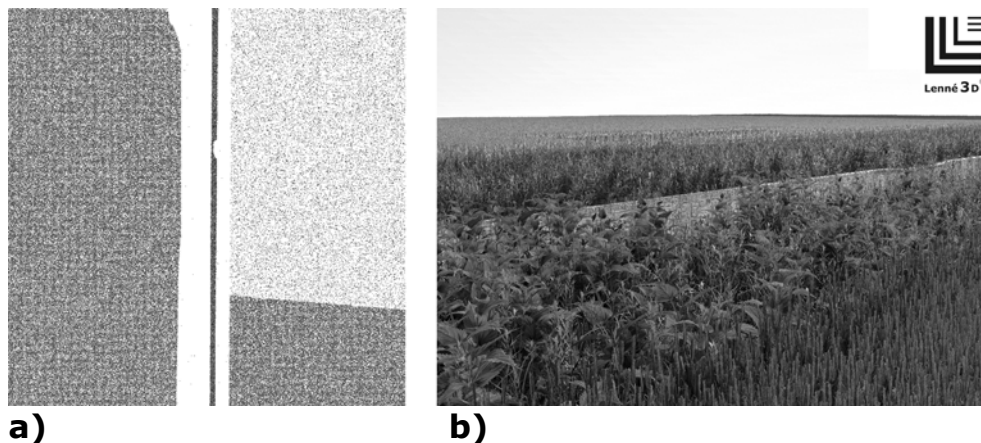
# **oik - nulla vita sine dispensatio.**

## **Vegetation Modelling for Landscape Planning**

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### **1 Introduction**

Within the Lenné3D<sup>®</sup> project, a German interdisciplinary research project sponsored by the German Federal Environmental Foundation (Deutsche Bundesstiftung Umwelt - DBU), the presented vegetation modelling tool, called oik<sup>®</sup>, handles the distribution of plant (models) on a given terrain (WERNER et al., 2005). An important constraint for such a distributor is the support of real time visualisation techniques by the associated 3D renderers. Thus the intention of the oik module is to generate a convincing, close-to-reality vegetation cover within a landscape through randomised or other, more or less sophisticated, but reasonable, algorithms.



**Fig. 1:** Example of oik plant distribution output: **a)** 2D map view (screenshot Lenné3D-oik) **b)** 3D view (screenshot Lenné3D-Player). Sample area Uckermark (Germany, Brandenburg)

There are different approaches for the production of so called "photorealistic" visualisation, but the potential of today's computer-graphic methods for and in landscape planning can only be foreshadowed. Modern methods, such as "pattern recognition" from orthophotos, "rapid feature extraction", laserscanning data and others will promise faster, more authentic and more automated visualisations of real landscapes in the near future (HOERSCH, 2001, TIEDE & BLASCHKE, 2005). Presently, the oik module computes the plant distribution of a given sample area on the basis of spatial data (in particular GIS data from landscape

planning), other scientific data (e. g. topographical, pedological, historical data and relevés), and results of environmental planning processes (Fig. 1).

## 2 Vegetation Modelling

### 2.1 Background

Procedures for the generation of individual plant models and the reproduction of plant cover in a virtual world are nearly as old as computer graphics techniques. With the development of computer hardware (consumer grade) toward the end of the twentieth century, the first complex plant populations could be reproduced within an acceptable time, for up to whole landscapes. Vegetation representation techniques have evolved for a variety of purposes, that within many professions, computer-generated plants are being used and scientific modelling is more successful at simulating ecological interrelations (DEUSSEN, 2003, HOERSCH, 2001, OSTENDORF, 1995, TAPPEINER et al., 1998 and others). In addition, a boom in the 3D-visualisation tool market can also be seen (3D NATURE, 2005 etc.).

Today's typical landscape modelling and visualisation pipeline in computer graphics follows in principle, the following four steps (DEUSSEN, 2003):

- modelling/ generation of 3D terrain
- computation of 2D plant distribution
- positioning/ instantiation of 3D plant models
- rendering, visualisation

Most efforts in computer graphics are focussed on the technological challenges of the subject. However, we will only look at the second step. The history of ecological modelling has seen many examples of plant cover modelling of a given terrain that are rather well-founded.

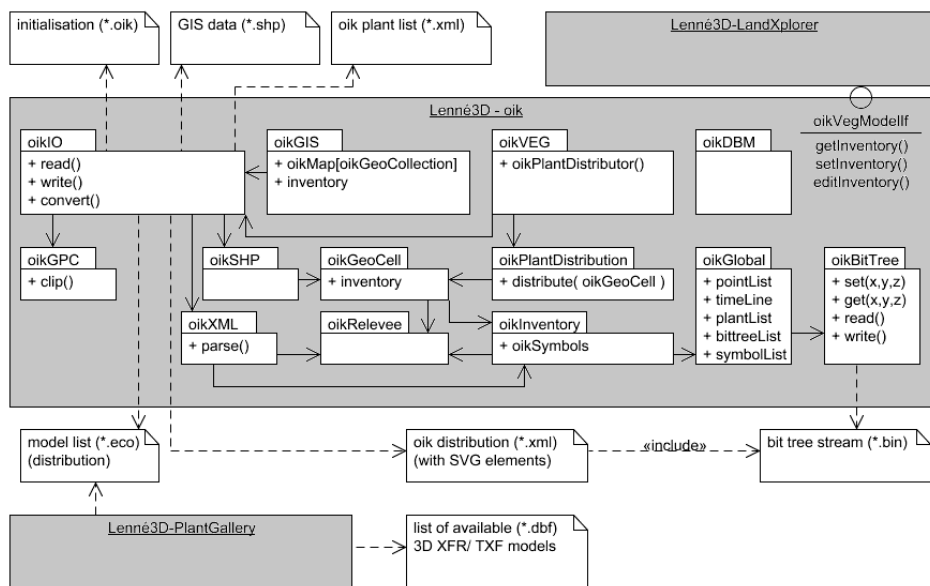
In vegetation science, the definition and classification of phytosociological units ("vegetation" in a pure scientific sense) result from correlative methods, such as phytosociological "tabulation work": where plants are listed within rows and columns of a relevé table which then are sorted by floristical criteria. Following that, causal analyses for further investigations could be carried out.

An exclusive causal approach makes the successful modelling of real landscapes an impracticable example. For according to HAGEN et al. (1993), "*The estimation of parameters (coefficients) for ecosystem models is a crucial task.*" In order to run a pure numerical simulation to model a complex real ecosystem, an abundance of exceptions and discrepancies between reality and simulated results needs to be identified. Despite all the innovative techniques described in many published scientific papers, today's ecological models are only capable of (more or less) uni- or low-factorial analyses. However, it is still necessary to carefully calibrate these ecosystem models. But a real ecosystem is made up of

multi-dimensional, multi-scaled interactions, and all the silicon power of today still can not run the real world.

Thus in computer graphics, the basic approach commonly handles the plant cover as a combination of single, so called plant "populations". Based on models of a single species, the distribution of many individual plants - as instances of the related representative(s) - is more or less sophisticatedly devised. In some cases the "plant colonisation" follows (one-factorial) pedological parameters (e. g. soil-moisture, DEUSSEN et al., 1998). In other cases, the distribution is designed/ created with no basis on real landscapes (cleverly sometimes indeed!). Other approaches and commercial products work with a system of pre-built ground cover textures, populated with trees and bushes (3D NATURE, 2005, HAMMES, 2001, WELLS, 2005 and others). The complexity of an ecosystem can be reduced, if the calculations are focused only on the tree inventory of a sample area (where the "extant" plants are "simply" handled as ground cover textures).

Within the known (yet published) virtual landscapes, about half a dozen of plant species are combined, with every taxon modelled by about 1 to 15 representatives (3D models) and every plant model by up to ten thousands, sometimes hundred thousands of instances (BENEŠ & GUERRERO, 2004). In published examples known to me, neither was there a real landscape (larger than a couple of square meters) modelled completely (with all the grasses, herbs, shrubs, and trees), nor was the modelled landscape used in a real time rendering.



**Fig. 2:** Sketch of oik module with interfaces to Lenné3D-PlantGallery and Lenné3D-LandXplorer. RÖHRICHT & CLASEN (2005).

## 2.2 oik: Ecological Interpretation of Maps

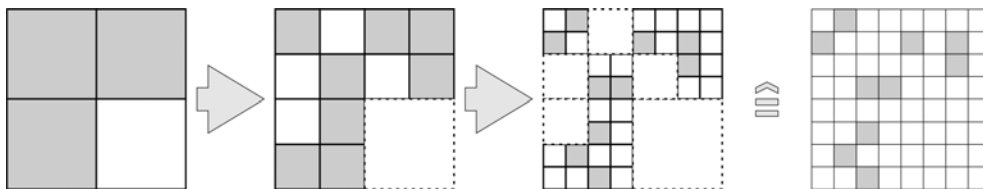
In the advancement of the above characterized approaches, Lenné3D-oik attempts to find a more interpretative, phytosociological way to build the plant distribution of a sample area: "*To know the plant distribution, one do not need to know the site-related factors, but the vegetation.*" (RÖHRICHT & CLASEN, 2005).

*Vegetation* modelling can be broken down into two stages (cf. Fig. 2). In the first stage, pedological maps and/ or (precomputed) relief data (e. g. altitude, exposition, slope) or other expert data are combined with vegetation referenced spatial data (e. g. maps of biotope types) to produce more or less homogeneous parts (so-called "geoCells") in the landscape (RÖHRICHT & WIELAND, 2004, RÖHRICHT & CLASEN, 2005). These clippings will then be combined with (preferably regionalised) relevé data at the next stage.

The dispersion of every plant (model) within the "geoCell" is automatically computed (Fig. 1), based on the sociability of the particular species (or on a manually given distribution path). Depending on the size of the sample area, hundreds of thousands, up to several billions of single plant individuals can result, whose locations must be turned over to the visualisation module(s). With the use of specific bit tree techniques, we are then able to process the resulting millions of individuals in each landscape.

## 2.3 Hierarchical Bit trees

To solve the problem of the resulting bulk of plant locations, the explicit storage of coordinates is changed to implicit storage through the method of hierarchical bit arrays, also known as bit trees (RÖHRICHT & CLASEN, 2005). The deployed bit tree uses a quadtree structure, that is similar to the representation of point sampled geometry in BOTSCH et al (2002). On each hierarchical level an element is partitioned into  $n$  (e. g. 4, 16, 64 ...) child elements. Large free ranges do not need to be dissolved up to the finest level, thus every single zero bit encodes a block of empty cells at the finest level (Fig. 3).



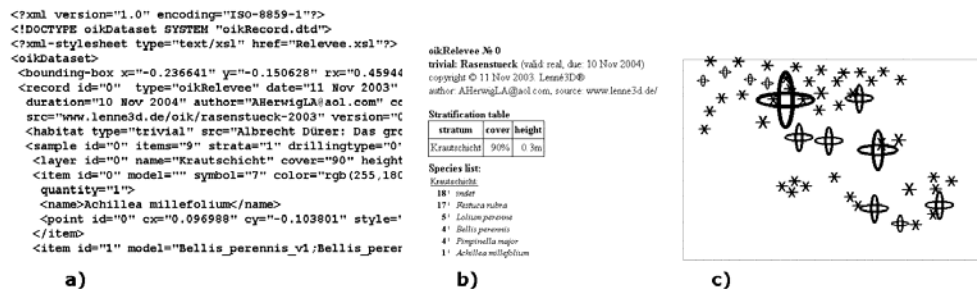
**Fig. 3:** Hierarchically organized bit trees. Dark fields with at least 1 individual/ sample point, zero-bits/empty cells not hatched. RÖHRICHT & CLASEN (2005).

### 3 Use in Landscape Planning and XML

The Lenné3D system addresses the issue of recognizable, close-to-reality presentations of planning objectives of landscape architecture and landscape planning, esp. within participation processes. This requires complication-free handling with typically used data.

With the use of common GIS based data formats, well-known phytosociological methods, and a transparent XML syntax, a beneficial coherence to the modus operandi of the landscape planner is produced. A well maintained database of phytosociological data (and the corresponding know-how) is a pre-condition, which is absolutely necessary for the decision procedure that allocates the reference relevés to the "geoCells" (see above).

Great importance was placed on high flexibility and integration of separate data models right from the start of the development of the Lenné3D. Along with common relational databases, vegetation interchange formats on the basis of the Extensible Markup Language (XML) are also becoming more and more accepted (DE CÁCERES et al., 2003, FLAXMAN, 2005 etc.). During the development of the vegetation data format used by oik, an XML-based format was created to store both relevé data and plant distribution data. Such a data model is human readable, editable with available editors, and reproducible from most database management systems. The universally kept syntax is also applicable for e. g. faunistical or pedological samples and allows for future development of ecological modelling with oik.



**Fig. 4:** Different browser views to the same XML document. **a)** plain source text (partly) **b)** relevé style XSL transformation (partly) **c)** pseudo-graphical plant distribution XSL transformation

The root element of the XML document is called *oikDataset* and contains 1..n *records*. Every *record* contains 1..n *samples* and every *sample* contains 0..n *levels* and 1..n *items*. Either explicit locations or Braun-Blanquet cover scale values or distribution patterns (described by the *sociability* attribute of *item* (plant species) or SVG<sup>1</sup> elements, *svg:path* etc.) or a mix of all, can be stored, as well as, referenced to bit tree stored distributions. The data model also proposes a reference to an existing GIS (shape) file. Groups of attributes are defined at each level of document hierarchy to carry all the information of

<sup>1</sup> SVG= Scalable Vector Graphics. see <http://www.w3.org/Graphics/SVG/>

related files, plant and model names, quantity, physical dimensions, distribution parameters, and others. The document type definition will be published after a stable version of the so called "oik inventory XML (OIX)" format is completed.

By defining different XSL Transformations<sup>2</sup>, the contents of the documents can not only be used by the oik module, but also viewed by XSL ready browsers (Fig. 4). In addition, the supplementary full integration of SVG elements will also render possible 2-dimensional graphical views.

## 4 Acknowledgments

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<sup>2</sup> XSL= Extensible Stylesheet Language. see <http://www.w3.org/TR/xslt>

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