Negotiation-support toolkit for learning landscapes

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16 Spatially explicit individual-based forest simulator (SExI-FS): for management of agroforests

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The Spatially Explicit Individual-based Forest Simulator (SExI-FS) simulates tree-to-tree interactions in multispecies agroforests. The model uses an object-oriented approach whereby each tree is individually modelled. Individual trees interact by modifying their neighbours' environment and competing for two major aboveground resources: space and light. An optimum scale for 3D representation of the agroforest plot is 1 hectare.

Introduction

The structural complexity of traditional agroforestry systems defies classical forestry approaches in optimizing management practices. To cope with this complexity, farmers have adopted tree-by-tree management, which is closer to gardening than to the usual tropical forestry or estate crop management model. Care and regular tending of individual trees can involve transplanting seedlings, selective cleaning and felling, and adjusting harvesting intensity.

The way that farmers approach these traditional systems appears to be in line with two basic tenets of biology: first, all individuals are different with their own particular behaviour and physiology resulting from a unique combination of genetic and environmental influences and, second, interactions are inherently local. Based on these premises, SExI-FS was developed to explore different management scenarios. SExI-FS provides insights about the critical processes and parameters of a system's dynamics in a complex agroforest. It also allows for the exploration of prospective management scenarios and helps with assessing the relevance of current management techniques. More direct applications of SExI-FS include using the model to compare the financial returns from alternative scenarios, such as the financial returns of rotational agroforests against those of permanent agroforests. The schematic diagram of SExI-FS is shown in Figure 16.2.

Objectives

The major objective of the model is to achieve a coherent and dynamic representation of a complex agroforestry system. This includes predicting the dynamic growth of a mixed-tree stand, its potential productivity and aspects of tree-growth competition. Graphical user interfaces help the user to explore various scenarios and plot designs and to predict the performance and productivity of each species' component (Figure 16.1).

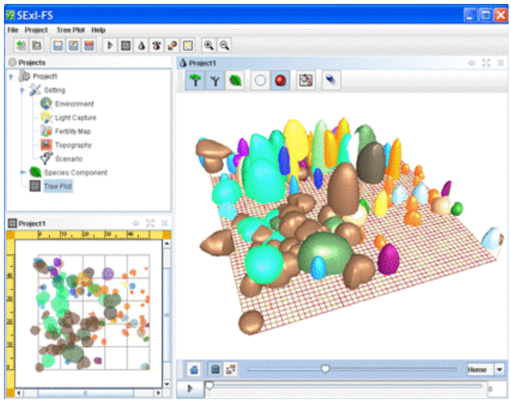

Figure 16.1. SExI-FS includes 3D visualization interfaces for a better view of a simulated scenario

Steps

SExI-FS (http://worldagroforestrycentre.org/regions/southeast_asia/resources/SExI-FS) runs on any platform that supports Java Virtual Machine (http://java.sun.com).

Species-specific parameterizations required for the model are: growth rate function, allometric relationship diameter at breast height (DBH) with height, allometric relationship of DBH with crown width and species' sensitivity to light. Ecological parameters include topography, soil-fertility map and parameters related to how light is captured by trees.

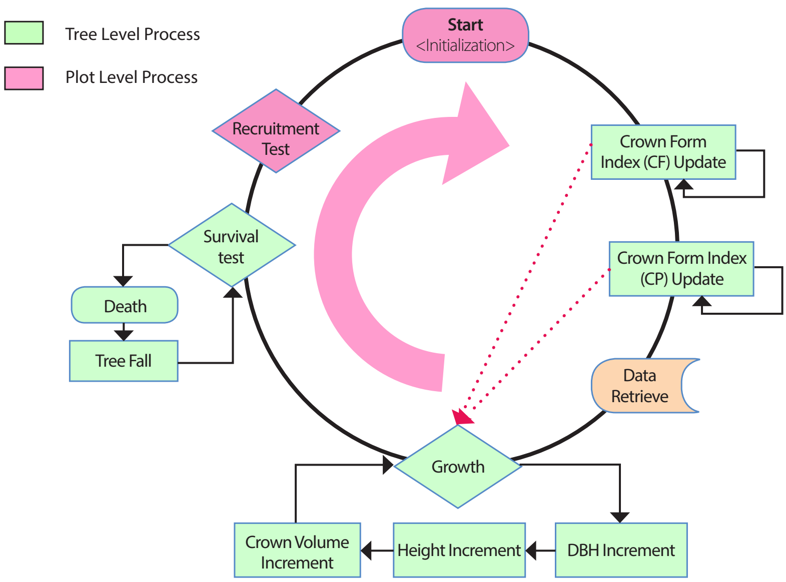

Figure 16.2. Main loop in the SExI-FS computer model. The loop runs on a yearly basis and starts with an initialization. Next, the tree-crown attributes, Crown Form Index (CF) and Crown Position Index (CP) are updated. Tree growth is then computed (diameter, height, and crown volume increment). At each step and for each tree, a survival test is undertaken. Finally at the stand level, a recruitment test is conducted

Case study: SExI-FS with RaLMA

SExI-FS has been used to explore the performance of various agroforestry scenarios (Harja et al 2005) and the potential role of trees in reducing the risk of landslides.

In the district of Bogor, West Java province, Indonesia, urban development had led to a significant reduction in tree cover and the conversion of agroforests to other land uses. This had triggered large landslides that caused the loss of lives as well as major economic losses and damage to infrastructure. In February 2007, about 300 households were considered to be at risk from landslides and were advised by the government to evacuate.

A bioengineering strategy for reducing land movement and preventing accidents requires information on the location of trees that have a confirmed capacity to anchor soil. The rate of root development will determine the options for stabilization. The study of areas at risk in Bogor could contribute to the development of prevention strategies, particularly in the context of climate-change adaptation, when the incidence of periods of extreme rainfall is expected to increase and the need for landslide prevention will become more pronounced.

The use of SExI-FS was aimed at exploring differences between tree species in terms of root development (in both the topsoil and in deeper layers of soil) that contribute to differences in soil binding and anchoring that can reduce downslope movement (at the level of the tree-root system).

Landslide risk needs to be evaluated at the hill-slope rather than at the tree level. For this reason, we recorded all trees in a 50 x 50 m plot and measured the indices of root anchoring (IRA) and binding (IRB) of tree species under local conditions (Figure 16.3). The SExI-FS model was able to simulate the role that trees can play to reduce the risk of landslide by quantifying the IRA and IRB within a tree plot (Figure 16.4).

The result of simulations of plot-management sensitivity scenarios showed that it was better to maintain plot density at an optimum size. This is because increasing plot density above the optimum size does not significantly increase plot root binding (although plot root anchoring does increase).

The selection of species based on IRB and IRA (van Noordwijk et al 2006) values is an acceptable approach to reducing landslide risk. Other considerations are farmers' preferences and the costs and benefits of various agroforestry scenarios.

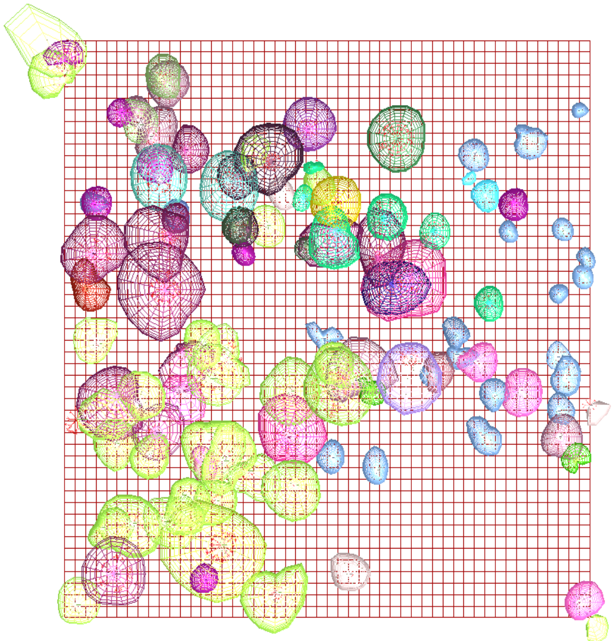

Figure 16.3. A schematic aerial view of all trees in a 50 x 50 m plot

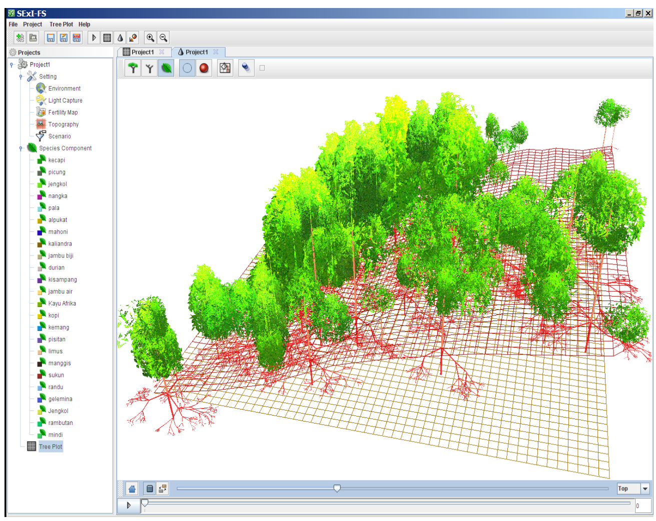

Figure 16.4. Representation of canopy and root systems in the 50 x 50 m plot using SExI-FS, showing how the trees' anchoring and binding function prevented landslides

■ Key reference

Harja D, Vincent G. 2008. *Spatially Explicit Individual-based Forest Simulator: user guide and software.* Bogor, Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program; Marseille, France: Institut de Recherche pour le Développement.

The landscape scale is a meeting point for bottom–up local initiatives to secure and improve livelihoods from agriculture, agroforestry and forest management, and top–down concerns and incentives related to planetary boundaries to human resource use.

Sustainable development goals require a substantial change of direction from the past when economic growth was usually accompanied by environmental degradation, with the increase of atmospheric greenhouse gasses as a symptom, but also as an issue that needs to be managed as such.

In landscapes around the world, active learning takes place with experiments that involve changes in technology, farming systems, value chains, livelihoods' strategies and institutions. An overarching hypothesis that is being tested is:

> Investment in institutionalising rewards for the environmental services that are provided by multifunctional landscapes with trees is a cost-effective and fair way to reduce vulnerability of rural livelihoods to climate change and to avoid larger costs of specific 'adaptation' while enhancing carbon stocks in the landscape.

Such changes can't come overnight. A complex process of negotiations among stakeholders is usually needed. The divergence of knowledge and claims to knowledge is a major hurdle in the negotiation process.

The collection of tools—methods, approaches and computer models—presented here was shaped by over a decade of involvement in supporting such negotiations in landscapes where a lot is at stake. The tools are meant to support further learning and effectively sharing experience towards smarter landscape management.

World Agroforestry Centre
ASB Partnership for the Tropical Forest Margins
AARD
Federal Ministry for Economic Cooperation and Development
Norad
IFAD Enabling poor rural people to overcome poverty
CGIAR Research Program on Forests, Trees, and Agroforestry