

LANDIS-II Project Charter

Purpose

Our research objective is to produce a forest landscape simulation model, LANDIS-II, designed to study the effects of interacting natural (fire, wind, insects, deer, etc.) and human disturbances (harvesting, climate change) on forest succession in large heterogeneous landscapes. The model will produce predictions that can be tested empirically, in whole or in part. LANDIS-II will have the capability to be parameterized for other ecosystems and conditions.

LANDIS-II will be comprised of three main ecological components: succession, seed dispersal, and disturbances. The succession component will be designed to work with multiple disturbance components that modify the landscape, such as windthrow, harvest, insects, and fire. Tree species will be represented in LANDIS-II as cohorts; each cohort is defined by species and age range, e.g., all maples 1 - 10 years old. In addition, LANDIS-II will allow additional information to be associated with each cohort. A succession routine that tracks biomass accumulation (aboveground net primary productivity - mortality) for each cohort has been designed and will be available as an optional succession component. Each disturbance type will be a component that can be modified and replaced as necessary. The model will allow new disturbance components to be added at will. Succession and seed dispersal can be replaced but are required. Finally, users will have the capability to select a time step that best fits the temporal scale of succession and disturbance within their ecosystem.

Background

The original LANDIS model was designed to model multiple disturbances (fire, wind, harvesting, insects) and succession across large (10^4 - 10^6 ha) landscapes. The LANDIS models utilize an approach similar to cellular automata, where the landscape is composed of many (up to 10^7) spatially interactive cells. Each cell is assigned to an ecoregion with homogeneous soil and climate. Trees are represented within LANDIS as species-age cohorts. Disturbances interact through their collective effects on forest succession, and through their influence on other system properties, e.g., fine and coarse fuel accumulation.

The last two-three years of research in LANDIS have been devoted to the development of a LANDIS model version (LANDIS 4.0) that can investigate multiple interacting disturbances, including wind, fire, harvest, and biological disturbances. The purpose of LANDIS 4.0 is to implement each of these disturbance modules as encapsulated optional components that can be turned on or off, depending on the research question. However, LANDIS 4.0 will not include any changes to the existing LANDIS design and code beyond that required to implement the new disturbance and fuel modules as separate components.

Two LANDIS research developments will require more extensive modifications to the model than simply connecting new modules. First, we decided to add the flexibility for cohorts to include additional information, such as aboveground biomass. Whether the disturbance components utilize this information is dependent upon the questions and hypotheses being addressed by the ecologist who designed that component. For example, biomass accumulation,

as designed by Scheller and Mladenoff (in press, Ecological Modelling), could change how the different modules communicate with each other and with the succession module. As a default, all disturbance components will utilize species and age cohort information when determining disturbance effects. The ability to use biomass information for determining disturbance effects will be added as necessary; some disturbances, e.g., wind, may never need to use the biomass information when determining disturbance effects.

Second, many ecologists have expressed interest in the implementation of a user-defined (i.e., variable) time step. In LANDIS 4.0 and previous versions, all processes operate at a 10-year time step. Although sufficient for northern hardwood forests, this has been a limitation for ecologists in other areas, particularly if short rotation fire or insects are a significant factor in forest succession.

Project Objectives

LANDIS will be redesigned into LANDIS-II from the “bottom-up”, resulting in an integrated but flexible landscape succession-disturbance model with flexible cohort information (species, age, and initially a biomass option) and a variable time step capability. The model will consist of a controller component and multiple, separate components that can be added as needed. Each component will be designed in the form of dynamic linkable libraries (dlls). The model will require succession and seed dispersal components as a minimum and these will be designed and implemented first. Inputs and outputs will also be designed as components that will be available for user modification. LANDIS-II will be designed to accept additional disturbance components so that other researchers will be able to create their own components and add them to LANDIS-II to suit their particular research needs. This will allow expanded usage of LANDIS-II as other research facilities will be able to design custom disturbance components for their particular needs.

The redesign of LANDIS offers us the opportunity to 1) improve computational efficiency through improvements to the code, 2) to remove both known and unknown sources of model error, 3) enhance the reusability of code through superior design, and 4) provide seamless and simplified integration among model components. The Unified Process Model (UPM) provides a standardized method of software design that can maximize the benefits and minimize the risks of LANDIS redesign. LANDIS redesign will follow the UPM methodology to ensure scientific integrity (i.e., the code is consistent with our conceptual model). This is achieved through responsibility-driven design, standardized incremental testing of model components, scientific review at critical stages of development, and the use of available Unified Modeling Language (UML) tools.

Deliverables

1. A forest landscape simulation model designed to study the effects of interacting natural and human disturbances on forest succession and fire risk in large heterogeneous landscapes. This program will be ready to use and fully documented for use.
2. A graphical user interface:
 - 2a. Will accept new modules as necessary.
 - 2b. Will create input windows for each module.

- 2b. Will allow multiple runs and scenarios to scheduled for execution.
3. A web site that will integrate all model information, news, publications, technical documentation, help files, etc. In addition, the web site will allow registered users to download and install new components as they become available. The option will exist for users to upload modified components to share with the model user community.
4. LANDIS-II will be fully documented and easy to maintain. Multiple levels of documentation will be provided, from scientific information for forest ecologists to technical, class level information for programmers and developers. Documentation will be provided as downloadable PDF files and on-line html documentation of classes.

Physical Scope

- Spatial Extent: large landscapes ~ 10^4 to 10^7 ha
- Spatial Resolution: 10x10 – 500x500 m
- Temporal Extent: 50 to 2000 years
- Temporal Resolution: 1-40 years
- Number of species: up to 100
- Operating System: Initially Windows OS
- Programming language: C#, although the use of dlls allows individual components to use other languages.