A new LANDIS-II module to study the effects of roads on forest landscapes

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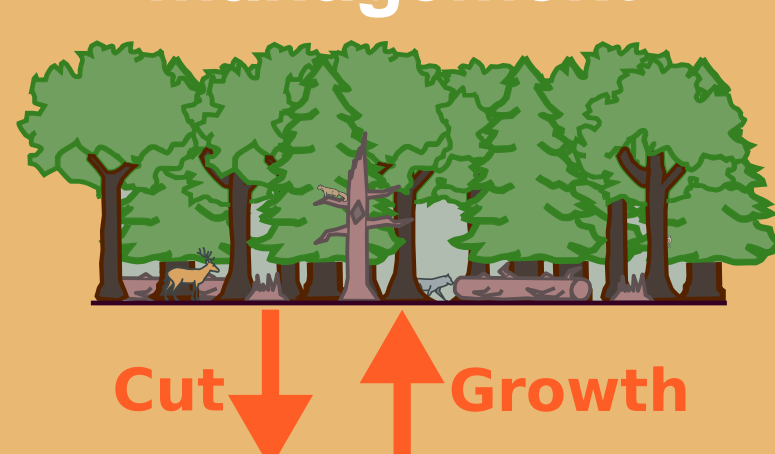
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1 Even or uneven-aged ?

The objective of this PhD is to compare the effects of even-aged and uneven-aged management on forests
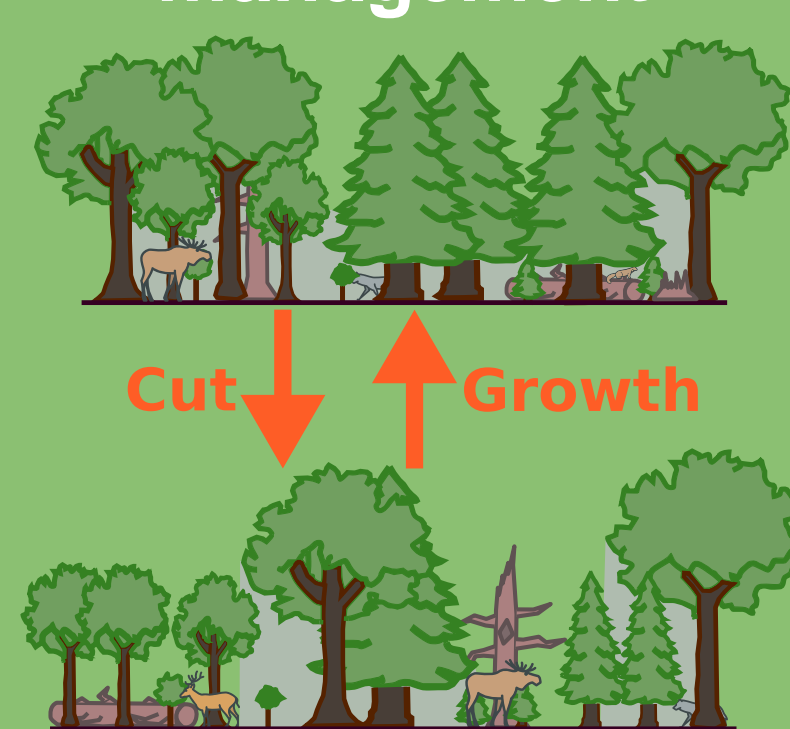
Even-aged management
Cut ↓ ↑ Growth

Uneven-aged management
Cut ↓ ↑ Growth

- Intensive and very productive
- Popular in North America
- Criticized for negative impacts on forest health [1]
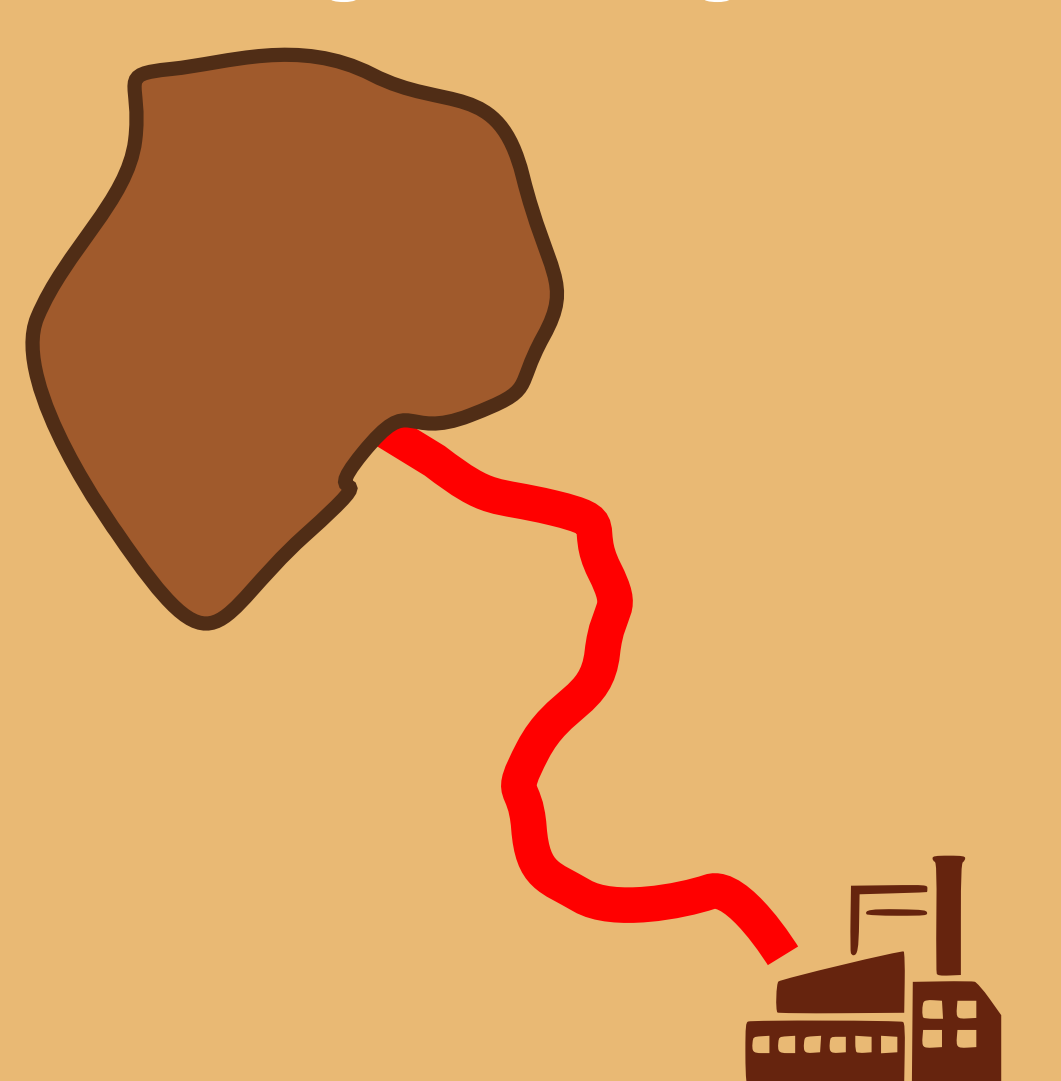
- Extensive but less productive
- Studies show positive effects on forest health [2]
- Trade-off harvest/conservation ?

Goal: determine the long-term and large-scale effects of uneven-aged management
Tool: Spatially explicit modelling.

→ There is a need for a study using spatially explicit modelling to explore this question at larger scales
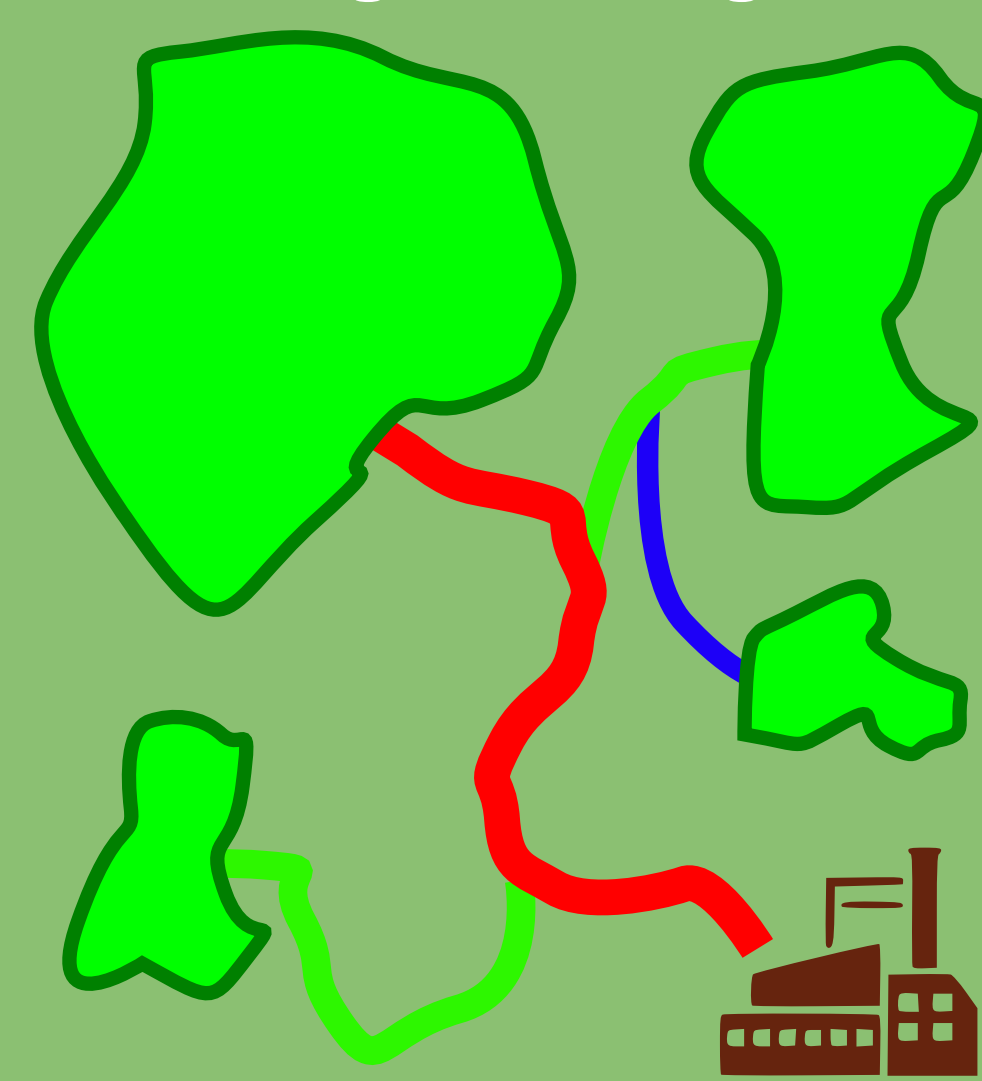
2 Impacts of forest roads on landscapes

My first chapter will compare even-aged and uneven-aged management through the use of forest roads.
Forest roads are a particular type of roads, but their creation and impacts are poorly studied [3].

Even-aged management
Uneven-aged management

- Sawmill
- Even-aged management
- Uneven-aged management
- Primary road
- Secondary road
- Tertiary road

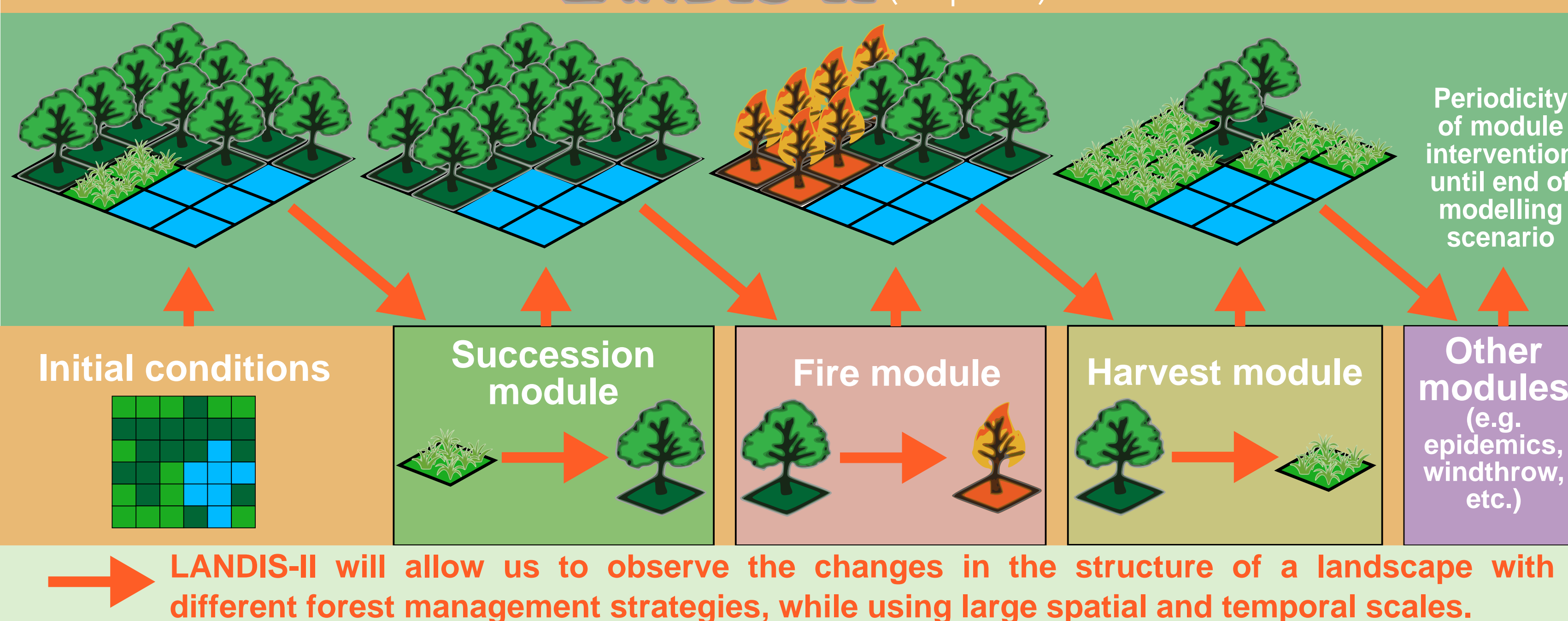Forest roads → Propagation of invasive species — Forest fires — Fragmentation

→ The effects of forest roads constructed to manage forests being uncertain at the landscape level, a new study is needed.

3 The LANDIS-II model

- LANDIS-II is a spatially explicit forest landscape model and a participative project
- Made of a core and different modules chosen by the user
- Validated in the literature and used all around the world
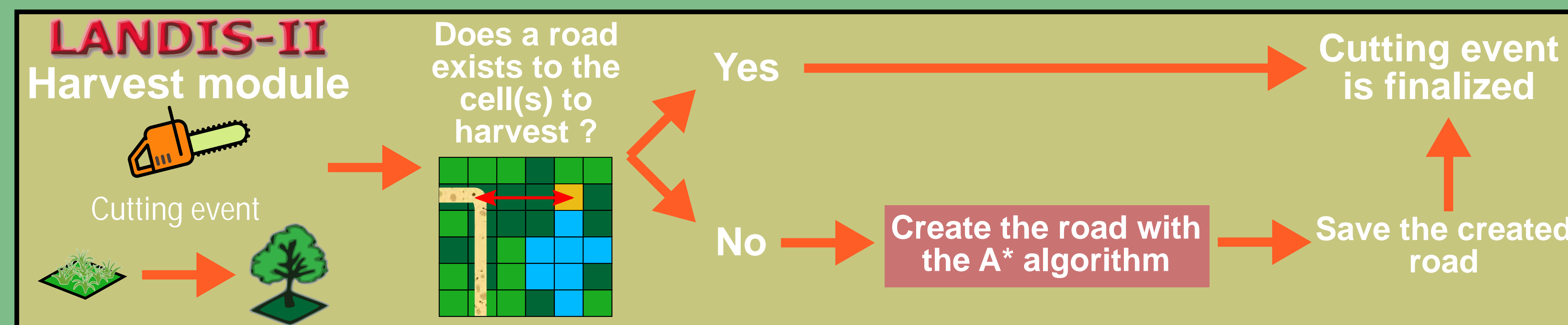- Modules can be developed by independent researchers

LANDIS-II (simplified)

Periodicity of module intervention until end of modelling scenario

Initial conditions → Succession module → Fire module → Harvest module → Other modules (e.g. epidemics, windthrow, etc.)

→ LANDIS-II will allow us to observe the changes in the structure of a landscape with different forest management strategies, while using large spatial and temporal scales.
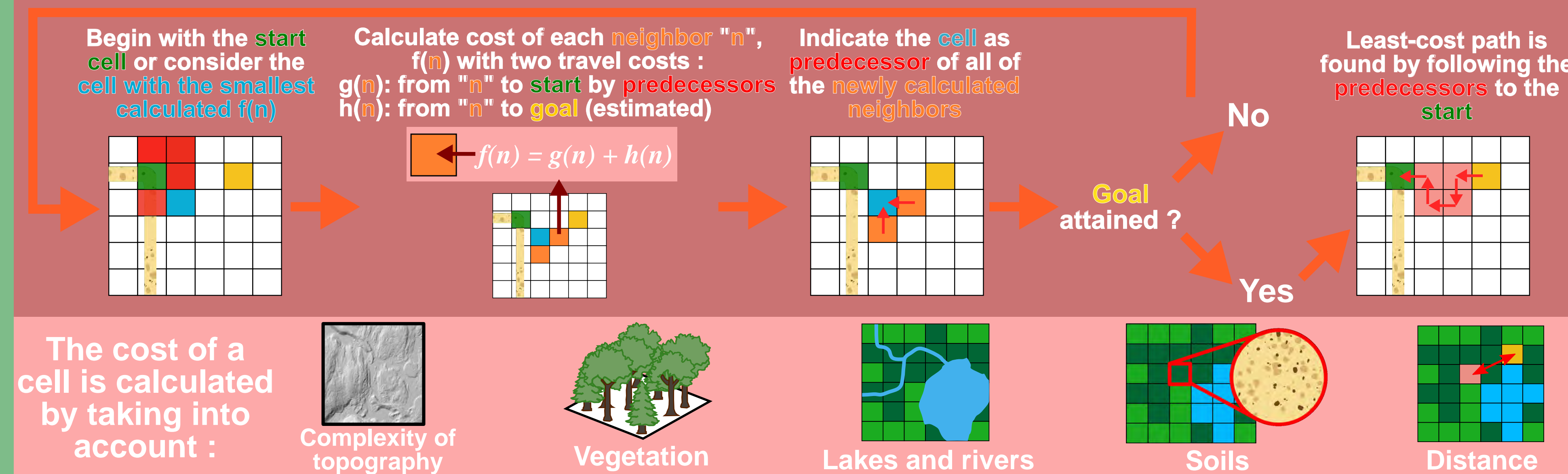
4 Modelling forest roads with the A* algorithm

LANDIS-II does not have a module that simulates forest roads creation. We will add one!

LANDIS-II Harvest module

Cutting event → Does a road exists to the cell(s) to harvest ?
— Yes → Cutting event is finalized
— No → Create the road with the A* algorithm → Save the created road

A* Algorithm [4]
Finds the least-cost path from the start cell (road) to the goal cell (harvest)

Begin with the start cell or consider the cell with the smallest calculated f(n) → Calculate cost of each neighbor "n", f(n) with two travel costs : g(n): from "n" to start by predecessors h(n): from "n" to goal (estimated)

$$f(n) = g(n) + h(n)$$

→ Indicate the cell as predecessor of all of the newly calculated neighbors → Goal attained ? — No / Yes → Least-cost path is found by following the predecessors to the start

The cost of a cell is calculated by taking into account : Complexity of topography — Vegetation — Lakes and rivers — Soils — Distance
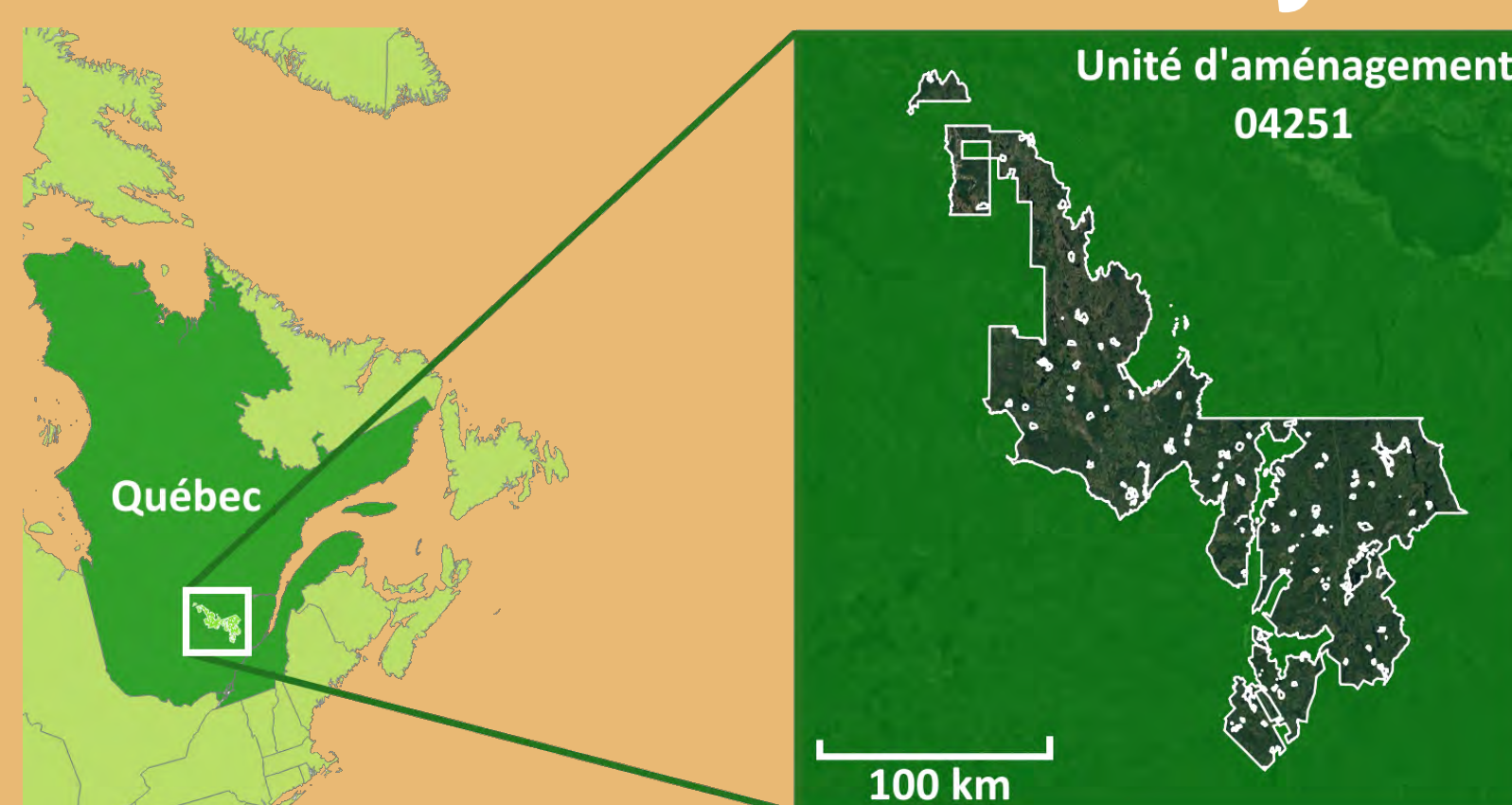
→ The A* algorithm can allow for a relatively fast way to compute a least-cost path on a raster according to complex costs, and can thus be integrated in LANDIS-II

5 Applications of forest roads modelling

Modelling of forest roads can have multiple applications in ecology. Our study is one example.
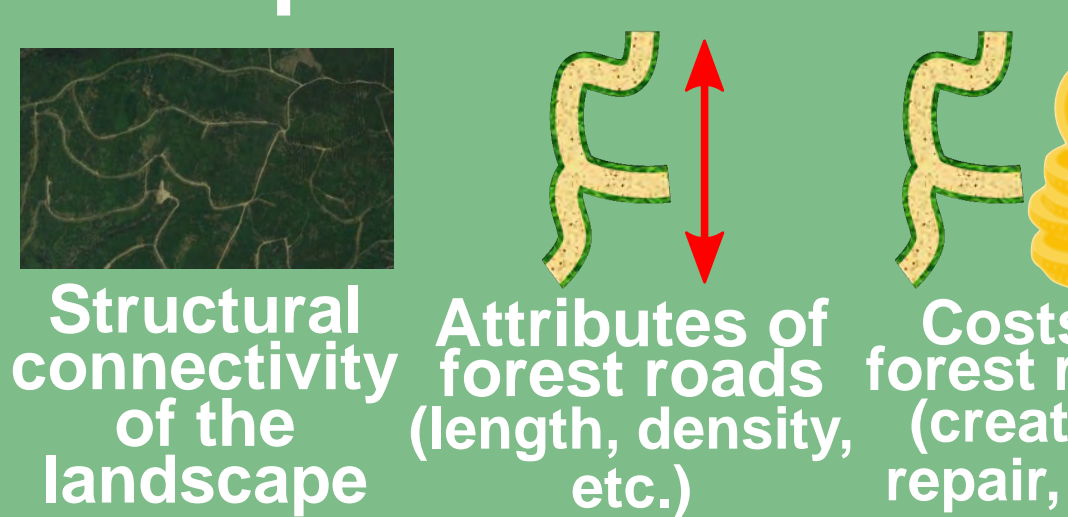
Our study
Québec — Unité d'aménagement 04251 — 100 km
300 simulated years

Independent variables
Forest management (proportion of even-aged and uneven-aged, surface harvested) | Initial road network (presence or absence)

Dependent variables
Structural connectivity of the landscape | Attributes of forest roads (length, density, etc.) | Costs of forest roads (creation, repair, etc.)

→ Forest roads being at the interface between human societies and forests, their modelling at the landscape scale can have many applications.

References

[1] Keenan, R. J. et al. (1993). The ecological effects of clear-cutting. Environmental Reviews, 1(2), 121-144
[2] Ruel, J.-C. et al. (2013). Partial cutting in old-growth boreal stands: An integrated experiment. The Forestry Chronicle, 89(03), 360-369
[3] Gucinski, H. (2001). Forest Roads: A Synthesis of Scientific Information. DIANE Publishing.
[4] Hart, P. E. et al. (1968). A Formal Basis for the Heuristic Determination of Minimum Cost Paths. IEEE Transactions, 4(2), 100-107

Acknowledgments