WALNUT DECLINE INJURY PROFILE SIMULATOR (IPSIM) MODEL: CONCEPTION METHODOLOGY FOR QUALITATIVE AGGREGATIVE MODELING

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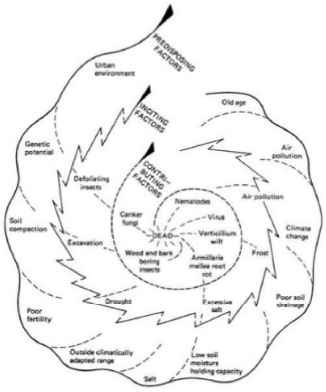
WALNUT DECLINE

Decline refers to the outwards expression of a state of stress in a woody plant due to environmental changes, resulting in the death of twigs as well as entire branches of the crown, and the receding appearance of numerous shoots lower and lower on the branches and trunk, as the declining tree loses vigor. Decline phenomena are increasingly observed in many tree species, including walnut (*Juglans* sp.), in forestry and arboriculture sectors in France and around the world, giving rise to great concern. These complex phenomena, induced by multiple biotic and abiotic factors (Landmann, 1994), are likely to become more frequent in the current context of climate change. To better grasp the complexity of the mechanisms involved and to characterize the interactions between the relevant influencing factors, modelling appears as a tool to better prevent and manage occurrences of decline events in walnut.



The "decline spiral" (Manion, 1991) based on Sinclair's concept of three successive gradations of decline factors (Landman, 1994).

BUILDING THE WALNUT DECLINE IPSIM MODEL

Medium-severity decline symptoms in an adult walnut specimen (J. regia cv. Franquette, grafted on 'wild' J. regia).

Bibliographical data, expert opinions and field observations

Steps 1, 2 and 3

co-construction workshops (growers, technicians). Selection of the relevant influencing factors and interactions, weight adjustement

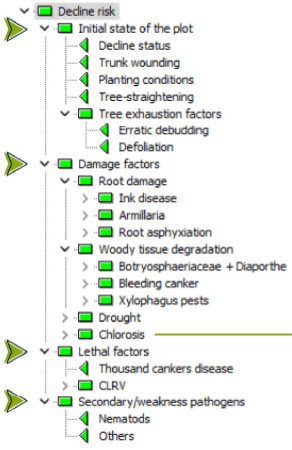
Step 4 (90 plots)

Steps 5 and 6

Model adjustment (IPSIM modeling is sensitive to overparameterization)

- Comparison of simulated and observed values
- Sensitivity analysis using *dexisensitivity* R package (Allart et al., 2025) to assess the relevance and respective impact of the selected influencing factors (parsimony)

BASELINE ARCHITECTURE

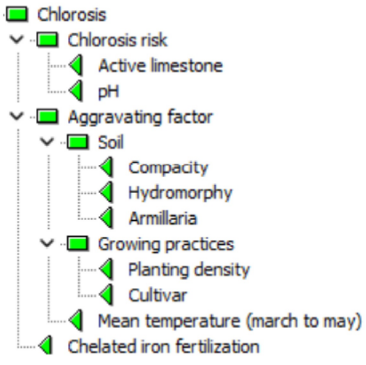


The general architecture of the model dictates the way in which the selected factors impacting walnut decline combine and compensate each other. Each rectangle indicates a submodel, one of which is detailed in the "focus example" section. Here, decline factors are classified into four main categories, highlighted by the ➤ symbol. Decline risk, the target variable, has three output levels: no to low risk, medium risk and high risk of decline occurrence.

Current baseline architecture of the walnut decline IPSIM model built with the DEXi software.

Current baseline architecture of the chlorosis submodel built with the DEXi software.

FOCUS EXAMPLE



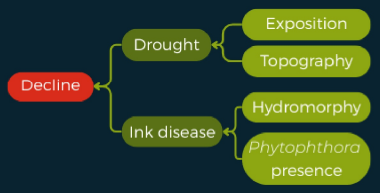
Chlorosis ✱ can lead to decline in walnut and is mainly triggered when pH exceeds 8 and when active limestone levels reach or exceed 5%. Chlorotic situations can be improved by adding chelated iron and can be aggravated by soil-related factors (compactness, hydromorphy, presence of *Armillaria mellea*), cultural factors (excessive planting density, sensitive cultivar) or meteorological factors, such as low spring temperatures.

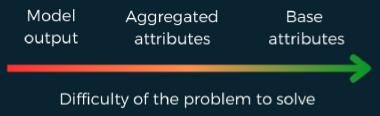
WHAT'S NEXT ? BIOCLIMSOL

Ultimately, to develop a practical decision-support tool for growers, this qualitative model will be combined to BioClimSol (Lemaire, 2018), an empirical quantitative model, i.e. a parametric equation assessing the suitability of a species to its growing location (prediction of decline probability based on soil related data and on current and predicted climate characteristics). IPSIM complements BioClimSol in its ability to take into account the impact of cultivation practices and biotic factors on the risk of decline.

IPSIM Injury Profile SIMulator

IPSIM (Aubertot and Robin, 2013) is a type of hierarchical, qualitative, aggregative modeling based on the DEX method (Bohanec, 2003). IPSIM models are built with the DEXi* software and allow a complex problem to be broken down into less complex problems, which are easier to solve independently :

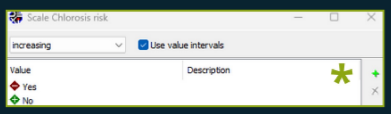




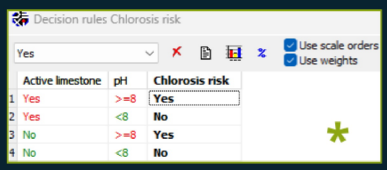
IPSIM models are generally built following five steps :

1 Defining attributes

Defining attribute scale **2**



3 Aggregation table construction



Database construction **4**

5 Model driving

Model performance assessment **6**

The model is trained and adjusted with one dataset and is statistically validated using another.

**DEXi (© Copyright 1999-2025) is a program for multiattribute decision making, developed in collaboration: Jožef Stefan Institute, Ljubljana Faculty of Organisational Sciences, Kranj Ministry of Education, Science and Sport of the Republic of Slovenia.*

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