Annex 1.1
Glossary of the terms frequently used in pest modelling

Algorithm. A precise rule (or set of rules) for solving some problem (CREM, 2009).
Analytical models. Models that can be solved mathematically in closed form. For example, some model algorithms that are based on relatively simple differential equations can be solved analytically to provide a single solution (CREM, 2009).
Assumptions. An assumption is a statement (true or false) which is to be taken as true for the purpose of the argument which follows. In order to abstract a model from reality, a set of assumptions has to be made. Some of these assumptions will be wrong and known to be so but are necessary for the process of abstraction. The key to successful modelling is to know which assumptions are likely to be wrong and to ensure that they are not important for the purpose for which the model is intended. Further, one should only use the model for that purpose and ensure that no-one else uses the model for purposes which render incorrect assumptions significant or correct assumptions invalid. The assumptions must be well understood and explicitly stated with reference to the conditions under which they are valid and, more importantly, the conditions under which they are invalid (Wainwright & Mulligan, 2004).
Bias. Systematic deviation between a measured (i.e., observed) or computed value and its "true" value. Bias is affected by faulty instrument calibration and other measurement errors, systematic errors during data collection, and sampling errors such as incomplete spatial randomization during the design of sampling programs (CREM, 2009).
Boundaries. The spatial and temporal conditions and practical constraints under which environmental data are collected. Boundaries specify the area or volume (spatial boundary) and the time period (temporal boundary) to which a decision will apply (CREM, 2009).
Boundary conditions. Sets of values for state variables and their rates along problem domain boundaries, sufficient to determine the state of the system within the problem domain (CREM, 2009).
Calibration. 1) The process of adjusting model parameters within physically defensible ranges until the resulting predictions give the best possible fit to the observed data. In some disciplines, calibration is also referred to as "parameter estimation" (CREM, 2009). 2) The adjustment of some parameters such that model behaviour matches a set of real-world data, it is a form of parameterization of models (CAMASE, 2009).
Code. Instructions, written in the syntax of a computer language, which provide the computer with a logical process. Code may also be referred to as computer program. The term code describes the fact that computer languages use a different vocabulary and syntax than algorithms that may be written in standard language (CREM, 2009).
Complexity. The opposite of simplicity. Complex systems tend to have a large number of variables, multiple parts, mathematical equations of a higher order, and are more difficult to solve. In relation to computer models, complexity generally refers to the level in difficulty in solving mathematically posed problems as measured by the time, number of steps or arithmetic operations, or memory space required (called time complexity, computational complexity, and space complexity, respectively) (CREM, 2009).
Conceptual basis. This is the underlying scientific foundation of model algorithms or governing equations. The conceptual basis for models is either empirical (based on

statistical relationships between observations) or mechanistic (process-based). See definitions for empirical model and mechanistic model (CREM, 2009).

Conceptual model. A hypothesis regarding the important factors that govern the behavior of an object or process of interest. This can be an interpretation or working description of the characteristics and dynamics of a physical system (CREM, 2009).

Constants. Quantities which have fixed values (e.g., the speed of light and the gravitational force) representing known physical, biological, or ecological activities (CREM, 2009).

Corroboration (model). Quantitative and qualitative methods for evaluating the degree to which a model corresponds to reality. In some disciplines, this process has been referred to as validation. In general, the term "corroboration" is preferred because it implies a claim of usefulness and not truth (CREM, 2009).

Debug. The identification and removal of bugs from computer code. Bugs are errors in computer code that range from typos to misuse of concepts and equations (CREM, 2009).

Decision making. Decision making can be regarded as an outcome of mental processes (cognitive process) leading to the selection of a course of action among several alternatives. Every decision making process produces a final choice. The output can be an action or an opinion of choice (Wikipedia, 2009).

Deterministic model. A model that provides a single solution for the state variables. Because this type of model does not explicitly simulate the effects of data uncertainty or variability, changes in model outputs are solely due to changes in model components (CREM, 2009).

Domain (spatial and temporal). The limits of space and time that are specified within a model's boundary conditions (see boundary conditions) (CREM, 2009).

Domain boundaries (spatial and temporal). The spatial and temporal domain of a model are the limits of extent and resolution with respect to time and space for which the model has been developed and over which it should be evaluated (CREM, 2009).

Empirical model. An empirical model is one where the structure is determined by the observed relationship among experimental data. These models can be used to develop relationships that are useful for forecasting and describing trends in behavior but they are not necessarily mechanistically relevant (CREM, 2009).

Evaluation. The judgement of the overall adequacy of the model. Evaluation includes several activities, including verification of internal consistency and units used, comparison of model output with an independent data set of real world observations, uncertainty analysis, and judgement of utility (CAMASE, 2009).

Expert system. An expert system is a software that attempts to reproduce the performance of one or more human experts, most commonly in a specific problem domain, and is a traditional application and/or subfield of artificial intelligence. A wide variety of methods can be used to simulate the performance of the expert however common to most or all are 1) the creation of a so-called "knowledgebase" which uses some knowledge representation formalism to capture the subject matter experts (SME) knowledge, and 2) a process of gathering that knowledge from the SME and codifying it according to the formalism, which is called knowledge engineering. Expert systems may or may not have learning components but a third common element is that once the system is developed it is proven by being placed in the same real world problem solving situation as the human SME, typically as an aid to human workers or a supplement to some information system (Wikipedia, 2009).

Extrapolation. Extrapolation is a process that uses assumptions about fundamental causes underlying the observed phenomena in order to project beyond the range of the data. In general, extrapolation is not considered a reliable process for prediction; however, there are situations where it may be necessary and useful (CREM, 2009).

False negatives. Also known as false acceptance decision errors. False negatives occur when the null hypothesis or baseline condition cannot be rejected based on the available sample data. The decision is made assuming the baseline condition is true when in reality it is false (CREM, 2009).

False positives. Also known as false rejection decision errors. False positives occur when the null-hypothesis or baseline condition is incorrectly rejected based on the sample data. The decision is made assuming the alternate condition or hypothesis to be true when in reality it is false (CREM, 2009).

Forcing/Driving variables. External or exogenous (outside the model framework) factors that influence the state variables calculated within the model. These may include, for example, climatic or environmental conditions (temperature, wind flow, oceanic circulation, etc.) (CREM, 2009).

Forecasting/ Prediction. The process of estimation in unknown situations. Prediction is a similar, but more general term. The terms "forecast" and "forecasting" are sometimes reserved for estimates of values at certain specific future times, while the term "prediction" is used for more general estimates, for instance, to find the value of the target attribute for unknown past or current situation (Wikipedia, 2009).

Forms (models). Models can be represented and solved in different forms, including analytic, stochastic, and simulation (CREM, 2009).

Function. A mathematical relationship between variables (CREM, 2009).

Measurement errors. Errors in the observed data that are a function of human or instrumental error during collection. Such errors may be independent or random. When a persistent bias or miscalibration is present in the measurement device, measurement errors may be correlated among observations. In some disciplines, measurement error may be referred to as observation error (CREM, 2009).

Mechanistic model. A model that has a structure that explicitly represents an understanding of physical, chemical, and/or biological processes. Mechanistic models quantitatively describe the relationship between some phenomenon and underlying first principles of cause. Hence, in theory, they are useful for inferring solutions outside of the domain that the initial data was collected and used to parameterize the mechanisms (CREM, 2009).

Model. A representation of the behavior of an object or process, often in mathematical or statistical terms. Models can also be physical or conceptual (CREM, 2009).

Model coding. The process of translating the mathematical equations that constitute the model framework into a functioning computer program (CREM, 2009).

Model framework uncertainty. The uncertainty in the underlying science and algorithms of a model. Model framework uncertainty is the result of incomplete scientific data or lack of knowledge about the factors that control the behaviour of the system being modelled. Model framework uncertainty can also be the result of simplifications necessary to translate the conceptual model into mathematical terms (CREM, 2009).

Model framework. The model framework is the system of governing equations that make up the mathematical model. It is a formal mathematical specification of the concepts and procedures of the conceptual model consisting of generalized algorithms (computer code/software) for different site or problem-specific simulations (CREM, 2009).

Module. An independent or self contained component of a model which is used in combination with other components and forms part of one or more larger programs (CREM, 2009).

Parameters. Terms in the model that are fixed during a model run or simulation but can be changed in different runs as a method for conducting sensitivity analysis or to achieve calibration goals (CREM, 2009).

Precision farming. Precision farming (or precision agriculture) is an agricultural concept relying on the existence of in-field variability. It's about doing the right thing, in the right place, in the right way, at the right time. It requires the use of new technologies, such as global positioning (GPS), sensors, satellites or aerial images, and information management tools (GIS) to assess and understand variations. Collected information may be used to more precisely evaluate optimum sowing density, estimate fertilizers and other inputs needs, and to more accurately predict crop yields. It seeks to avoid applying inflexible practices to a crop, regardless of local soil/climate conditions, and may help to better assess local situations of disease or lodging (Wikipedia, 2009).

Precision. The quality of being reproducible in amount or performance. With models and other forms of quantitative information, precision refers specifically to the number of decimal places to which a number is computed as a measure of the “preciseness” or “exactness” with which a number is computed (CREM, 2009).

Programs (computer). Instructions, written in the syntax of a computer language, that provide the computer with a step-by-step logical process. Computer programs are also referred to as code (CREM, 2009).

Reliability. The confidence that (potential) users have in a model and in the information derived from the model such that they are willing to use the model and the derived information. Specifically, reliability is a function of the performance record of a model and its conformance to best available, practicable science (CREM, 2009).

Robustness. The capacity of a model to perform equally well across the full range of environmental conditions for which it was designed (CREM, 2009).

Sensitivity. Sensitivity concerns the study of model properties through - not necessarily realistically sized - changes in the input variables and the analysis of its effect on model outputs (CAMASE, 2009).

Simulation. Simulation is an attempt to model the real-world or hypothetical situation (usually on a computer) so that it can be studied to see how the system works. By changing variables, predictions may be made about the behaviour of the system. Computer simulation has become a useful part of modelling many natural systems, biology included, to gain insight into the operation of those systems. Traditionally, the formal modelling of systems has been via a mathematical model, which attempts to find analytical solutions enabling the prediction of the behaviour of the system from a set of parameters and initial conditions. There are many different types of simulation, the common feature they all share is the attempt to generate a sample of representative scenarios for a model in which a complete enumeration of all possible states would be prohibitive or impossible (Wikipedia, 2009).

Simulation models. Simulation models are used to obtain solutions for more models that are too complex to be solved analytically. In general, simulation models provide approximations of the mathematical solutions. For most situations, where a differential equation is being approximated, the simulation model will use finite time step (or spatial step) to "simulate" changes in state variables over time (or space) (CREM, 2009).

State variables. The dependent variables calculated within the model, which are also often the performance indicators of the models that change over the simulation (CREM, 2009).

Statistical models. Simple linear or multivariate regression models obtained by fitting observational data to a mathematical function (CREM, 2009).

Stochastic model. A model that includes variability (see definition) in model parameters. This variability is a function of: 1) changing environmental conditions, 2) spatial and temporal aggregation within the model framework, 3) random variability. The solutions obtained by the model or output is therefore a function of model components and random variability (CREM, 2009).

Stochasticity. Fluctuations in ecological processes that are due to natural variability and inherent randomness (CREM, 2009).

Transparency. The clarity and completeness with which data, assumptions and methods of analysis are documented. Experimental replication is possible when information about modeling processes is properly and adequately communicated (CREM, 2009).

Uncertainty. The term used in this guidance to describe lack of knowledge about models, parameters, constants, data, and beliefs. There are many sources of uncertainty, including the science underlying a model, uncertainty in model parameters and input data, observation error, and code uncertainty. Additional study and collecting more information allows error that stems from uncertainty to be minimized/reduced (or eliminated). In contrast, variability (see definition) is irreducible but can be better characterized or represented with further study (CREM, 2009).

Uncertainty (of inputs and outputs). In this context, it is the uncertainty at the level of inputs and output of the model. Input uncertainty is caused by natural variation (e.g. weather, soil or genetic variation) as well as by imperfection of data. Although the causes of uncertainties may differ, their effect is the same, namely uncertainty about the model outputs. In most studies, uncertainty analysis is the study of output uncertainty as a function of a careful inventory of the different sources of uncertainty present in the model. Large uncertainty contributions of individual inputs or groups of inputs to model output indicate that it is worthwhile to know more about these (groups of) inputs, whereas it is pointless to gain new information about other inputs (CAMASE, 2009).

Uncertainty (of the model). In this context, it is imperfect knowledge regarding the system to be modelled or at the level of model formulation.

Uncertainty analysis. Investigates the effects of lack of knowledge or potential errors on the model (e.g, the "uncertainty" associated with parameter values) and when conducted in combination with sensitivity analysis (see definition) allows a model user to be more informed about the confidence that can be placed in model results (CREM, 2009).

Validation. The term is used here in its most common utilitarian sense of establishing the usefulness and relevance of a model for a predefined purpose, in case of predictive models, a major part of the validation consists of an assessment of prediction accuracy. The purpose for what the model was validated may be made explicit. The validation data should be representative for the situations in which the model is to be used. The validation set should -if possible- cover the range of situations encountered in predictions (CAMASE, 2009).

Variability. Variability refers to observed differences attributable to true heterogeneity or diversity. Variability is the result of natural random processes and is usually not reducible by further measurement or study (although it can be better characterized) (CREM, 2009).

Variable. A measured or estimated quantity which describes an object or can be observed in a system and which is subject to change (CREM, 2009).

Verification. The term designates the inspection of the internal consistency of the model. Some important elements are: analysis of dimensions and units, checks on mass conservation, detection of violation of natural ranges of parameters and variables. Verification also comprises inspection of qualitative behaviour of the model and its implementation, e.g. a check whether the response of one model output to changing values of one parameter conforms to theoretical insights (CAMASE, 2009).

Verification (code). Examination of the algorithms and numerical technique in the computer code to ascertain that they truly represent the conceptual model and that there are no inherent numerical problems with obtaining a solution (CREM, 2009).

Warning. A warning system is any system of biological or technical nature deployed by an individual or group to inform of a future danger. Its purpose is to enable the deployer of the warning system to prepare for the danger and act accordingly to mitigate against or avoid it (Wikipedia, 2009). In this context, warnings are provided by public or private services and are offered to farmers by different modes of transmission, with the aim of controlling plant pests.

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Annex 1.2
MOPEST DATABASE STRUCTURE
(main tables)

SHEET 1 TABLE

Column Name	Data Type	Nullable	Default	Primary Key
ID	NUMBER	No	-	1
AUTHOR	VARCHAR2(1000)	Yes	-	-
INSTITUTION	VARCHAR2(1000)	Yes	-	-
PHONE	VARCHAR2(1000)	Yes	-	-
FAX	VARCHAR2(1000)	Yes	-	-
ADDRESS	VARCHAR2(1000)	Yes	-	-
CITY	VARCHAR2(1000)	Yes	-	-
ADMIN_AREA	VARCHAR2(1000)	Yes	-	-
POST_CODE	VARCHAR2(1000)	Yes	-	-
COUNTRY	VARCHAR2(1000)	Yes	-	-
EMAIL	VARCHAR2(1000)	Yes	-	-
ONLINE_CONTACT	VARCHAR2(1000)	Yes	-	-
HOURS_SERVICE	VARCHAR2(1000)	Yes	-	-
CNT_INSTRUCTION	VARCHAR2(1000)	Yes	-	-
YEAR	NUMBER	Yes	-	-
TITLE	VARCHAR2(1000)	Yes	-	-
OTH_BIB_INFO	VARCHAR2(4000)	Yes	-	-
LINK_PDF	VARCHAR2(1000)	Yes	-	-
LINK_PUB_SITE	VARCHAR2(1000)	Yes	-	-
LINK_EFSA_LIB	VARCHAR2(1000)	Yes	-	-
AUTHOR_2	VARCHAR2(1000)	Yes	-	-
YEAR_2	NUMBER	Yes	-	-
TITLE_2	VARCHAR2(1000)	Yes	-	-
OTH_BIB_INFO_2	VARCHAR2(4000)	Yes	-	-
LINK_PDF_2	VARCHAR2(1000)	Yes	-	-
LINK_PUB_SITE_2	VARCHAR2(1000)	Yes	-	-
LINK_EFSA_LIB_2	VARCHAR2(1000)	Yes	-	-
AUTHOR_3	VARCHAR2(1000)	Yes	-	-
YEAR_3	NUMBER	Yes	-	-
TITLE_3	VARCHAR2(1000)	Yes	-	-
OTH_BIB_INFO_3	VARCHAR2(4000)	Yes	-	-
LINK_PDF_3	VARCHAR2(1000)	Yes	-	-
LINK_PUB_SITE_3	VARCHAR2(1000)	Yes	-	-
LINK_EFSA_LIB_3	VARCHAR2(1000)	Yes	-	-
AUTHOR_4	VARCHAR2(1000)	Yes	-	-
YEAR_4	NUMBER	Yes	-	-
TITLE_4	VARCHAR2(1000)	Yes	-	-
OTH_BIB_INFO_4	VARCHAR2(4000)	Yes	-	-
LINK_PDF_4	VARCHAR2(1000)	Yes	-	-
LINK_PUB_SITE_4	VARCHAR2(1000)	Yes	-	-
LINK_EFSA_LIB_4	VARCHAR2(1000)	Yes	-	-
AUTHOR_5	VARCHAR2(1000)	Yes	-	-
YEAR_5	NUMBER	Yes	-	-
TITLE_5	VARCHAR2(1000)	Yes	-	-
OTH_BIB_INFO_5	VARCHAR2(4000)	Yes	-	-
LINK_PDF_5	VARCHAR2(1000)	Yes	-	-

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LINK_EFSA_LIB_5	VARCHAR2(1000)	Yes	-	-
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ADD_LINK_2	VARCHAR2(1000)	Yes	-	-
CT_LAST_NAME	VARCHAR2(1000)	Yes	-	-
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CT_INSTITUTION	VARCHAR2(1000)	Yes	-	-
CT_PHONE	VARCHAR2(1000)	Yes	-	-
CT_FAX	VARCHAR2(1000)	Yes	-	-
CT_ADDRESS	VARCHAR2(1000)	Yes	-	-
CT_CITY	VARCHAR2(1000)	Yes	-	-
CT_ADMIN_AREA	VARCHAR2(1000)	Yes	-	-
CT_POST_CODE	VARCHAR2(1000)	Yes	-	-
CT_COUNTRY	VARCHAR2(1000)	Yes	-	-
CT_EMAIL	VARCHAR2(1000)	Yes	-	-
CT_ONLINE_CONTACT	VARCHAR2(1000)	Yes	-	-
CT_HOURS_SERVICE	VARCHAR2(1000)	Yes	-	-
CT_CNT_INSTRUCTION	VARCHAR2(1000)	Yes	-	-
CT_DEP_FAC	VARCHAR2(1000)	Yes	-	-
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DATE_LAST_PROF	DATE	Yes	-	-
FULL_NAME_MOD	VARCHAR2(1000)	Yes	-	-
ACRONYM	VARCHAR2(1000)	Yes	-	-
VERSION	VARCHAR2(1000)	Yes	-	-
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MITES	NUMBER	Yes	-	-
ID_EPPO_CODE_2	VARCHAR2(1000)	Yes	-	-
NEMATODES	NUMBER	Yes	-	-
ID_EPPO_CODE_3	VARCHAR2(1000)	Yes	-	-
FUNGIS	NUMBER	Yes	-	-
ID_EPPO_CODE_4	VARCHAR2(1000)	Yes	-	-
BACTERIAS	NUMBER	Yes	-	-
ID_EPPO_CODE_5	VARCHAR2(1000)	Yes	-	-
PHYTOS	NUMBER	Yes	-	-
ID_EPPO_CODE_6	VARCHAR2(1000)	Yes	-	-
VIRUSES	NUMBER	Yes	-	-
PEST_CODE_EPPO	VARCHAR2(1000)	Yes	-	-
OTHERS	NUMBER	Yes	-	-
OTHER_TXT	VARCHAR2(1000)	Yes	-	-
ID_AUTHOR_2	NUMBER	Yes	-	-
ID_AUTHOR_3	NUMBER	Yes	-	-
ID_AUTHOR_4	NUMBER	Yes	-	-
ID_AUTHOR_5	NUMBER	Yes	-	-
PROFILE_CREATION	DATE	Yes	-	-
PROFILE_MODIFICATION	DATE	Yes	-	-
ID_AUTHOR	VARCHAR2(100)	Yes	-	-
PLANT_CODE_EPPO	VARCHAR2(1000)	Yes	-	-
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SOURCE	VARCHAR2(4000)	Yes	-	-
ISBN	VARCHAR2(1000)	Yes	-	-
ISSN	VARCHAR2(4000)	Yes	-	-

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NAME_PUBLISHER	VARCHAR2(4000)	Yes	-	-
COUNTRY_PUBLISHER	VARCHAR2(1000)	Yes	-	-
LOCATION_PUBLISHER	VARCHAR2(1000)	Yes	-	-
AVAILABILITY	VARCHAR2(4000)	Yes	-	-
LANGUAGE_TEXT	VARCHAR2(4000)	Yes	-	-
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PUBLICATION_TYPE_TXT	VARCHAR2(4000)	Yes	-	-
PEST_CODE_EPPO_TXT	VARCHAR2(4000)	Yes	-	-
PLANT_CODE_EPPO_TXT	VARCHAR2(4000)	Yes	-	-

SHEET 2 TABLE

Column Name	Data Type	Nullable	Default	Primary Key
ID	NUMBER	No	-	1
ID_MOPEST	NUMBER	Yes	-	-
KEYWORDS	VARCHAR2(1000)	Yes	-	-
FROM_PAPER	VARCHAR2(4000)	Yes	-	-
ADDITIONAL	VARCHAR2(4000)	Yes	-	-
CROP_SCIENCE	NUMBER	Yes	-	-
SOIL_SCIENCE	NUMBER	Yes	-	-
ENVI_SCIENCE	NUMBER	Yes	-	-
PEST_SCIENCE	NUMBER	Yes	-	-
FOOD_SCIENCE	NUMBER	Yes	-	-
AGRI_SCIENCE	NUMBER	Yes	-	-
OTHER_SCIENCE	NUMBER	Yes	-	-
OTHER_SCIENCE_TXT	VARCHAR2(1000)	Yes	-	-
ID_MODEL_TYPE	VARCHAR2(100)	Yes	-	-
ID_MODEL_TYPE_2	VARCHAR2(100)	Yes	-	-
ID_MODEL_TYPE_3	VARCHAR2(100)	Yes	-	-
EXEC_AVAILABLE	NUMBER	Yes	-	-
DOWNLOAD_LINK	VARCHAR2(1000)	Yes	-	-
DOWNLOAD_MADE	NUMBER	Yes	-	-
LINK_DOWNLOAD	VARCHAR2(1000)	Yes	-	-
DOWNLOAD_VER	VARCHAR2(1000)	Yes	-	-
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DATE_LAST_DOWLD	DATE	Yes	-	-
HW_REQ	VARCHAR2(1000)	Yes	-	-
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CT_TS_PHONE	VARCHAR2(1000)	Yes	-	-
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CT_TS_ADMIN_AREA	VARCHAR2(1000)	Yes	-	-
CT_TS_POST_CODE	VARCHAR2(1000)	Yes	-	-
CT_TS_COUNTRY	VARCHAR2(1000)	Yes	-	-
CT_TS_EMAIL	VARCHAR2(1000)	Yes	-	-
CT_TS_ONLINE_CONTACT	VARCHAR2(1000)	Yes	-	-
CT_TS_HOURS_SERVICE	VARCHAR2(1000)	Yes	-	-
CT_TS_CNT_INSTRUCTION	VARCHAR2(1000)	Yes	-	-
ID_OP_SYSTEM	VARCHAR2(100)	Yes	-	-

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ADD_INFOS	VARCHAR2(1000)	Yes	-	-
FLOW_DIAGRAM_LINK	VARCHAR2(1000)	Yes	-	-
MATH_INFO	VARCHAR2(4000)	Yes	-	-
DOC_INFO_LINK	VARCHAR2(1000)	Yes	-	-
ASSUMPTION	VARCHAR2(4000)	Yes	-	-
MOD_UNCERTAINTY	VARCHAR2(1000)	Yes	-	-
PEST_ORGANISM	NUMBER	Yes	-	-
PEST_POPULATION	NUMBER	Yes	-	-
PEST_META_POPULATION	NUMBER	Yes	-	-
PEST_OTHER	NUMBER	Yes	-	-
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HOST_PLANT	NUMBER	Yes	-	-
HOST_CROP	NUMBER	Yes	-	-
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HOST_FARM	NUMBER	Yes	-	-
HOST_ECOSYSTEM	NUMBER	Yes	-	-
HOST_LANDSCAPE	NUMBER	Yes	-	-
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FRENCH	NUMBER	Yes	-	-
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TO_TEMP_COVERAGE	DATE	Yes	-	-
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COVERAGE_COUNTRIES	VARCHAR2(1000)	Yes	-	-
COVERAGE_COUNTRY_SUBDIVISIONS	VARCHAR2(1000)	Yes	-	-
LAND_USE_STUDIES	NUMBER	Yes	-	-
CROP_PROTECTION	NUMBER	Yes	-	-
FORESTRY	NUMBER	Yes	-	-
FARMING_SYSTEMS	NUMBER	Yes	-	-
DAY_FROM	NUMBER	Yes	-	-
MONTH_FROM	NUMBER	Yes	-	-
DAY_TO	NUMBER	Yes	-	-
MONTH_TO	NUMBER	Yes	-	-
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APPLICABLE_TEMPORAL_COVERAGE	NUMBER	Yes	-	-
EXECUTABLE_EXISTS	NUMBER	Yes	-	-
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COVERAGE_COUNTRY_SUB_TXT	VARCHAR2(4000)	Yes	-	-
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MODE_TYPE_TXT_2	VARCHAR2(4000)	Yes	-	-
MODE_TYPE_TXT_3	VARCHAR2(4000)	Yes	-	-
COVERAGE_CONTINENTS_TXT	VARCHAR2(4000)	Yes	-	-
OP_SYSTEM_TXT	VARCHAR2(4000)	Yes	-	-

SHEET 3 TABLE

Column Name	Data Type	Nullable	Default	Primary Key
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SENSOR_TYPE	VARCHAR2(1000)	Yes	-	-
DOC_SENSOR_TYPE	VARCHAR2(1000)	Yes	-	-
ID_CALC_VAR	VARCHAR2(4000)	Yes	-	-
MET_CALCULATION	VARCHAR2(1000)	Yes	-	-
DOC_MET_CALC	VARCHAR2(1000)	Yes	-	-
ID_MEAS_TIME	VARCHAR2(1000)	Yes	-	-
ID_SENS_LOC	VARCHAR2(1000)	Yes	-	-
DETAILS_LOCA	VARCHAR2(1000)	Yes	-	-
ID_PEST_VAR	VARCHAR2(1000)	Yes	-	-
DETAILS_PEST_VAR	VARCHAR2(1000)	Yes	-	-
DOC_PEST_VAR	VARCHAR2(1000)	Yes	-	-
ID_MEAS_TIME_2	VARCHAR2(1000)	Yes	-	-
ID_HOST_VAR	VARCHAR2(1000)	Yes	-	-
DETAILS_HOST	VARCHAR2(1000)	Yes	-	-
DOC_HOST	VARCHAR2(1000)	Yes	-	-
ID_MEAS_TIME_3	VARCHAR2(1000)	Yes	-	-
INPUT_OTHER_TXT	VARCHAR2(1000)	Yes	-	-
QUALITATIVE	NUMBER	Yes	-	-
QUANTITATIVE	NUMBER	Yes	-	-
PROBABILITY	NUMBER	Yes	-	-
RISK	NUMBER	Yes	-	-
PEST	NUMBER	Yes	-	-
LOSSES	NUMBER	Yes	-	-
OUTPUT_OTHER	NUMBER	Yes	-	-
OUTPUT_OTHER_TXT	NUMBER	Yes	-	-
ID_PEST	VARCHAR2(1000)	Yes	-	-
DESC_PEST	VARCHAR2(1000)	Yes	-	-
DOC_PEST	VARCHAR2(1000)	Yes	-	-
ID_LOSS	VARCHAR2(1000)	Yes	-	-
DESC_LOSS	VARCHAR2(1000)	Yes	-	-
DOC_LOSS	VARCHAR2(1000)	Yes	-	-
VALIDATION	NUMBER	Yes	-	-
N_VALIDATION	VARCHAR2(1000)	Yes	-	-
ID_METHOD_USED	VARCHAR2(1000)	Yes	-	-
VERIFICATION	NUMBER	Yes	-	-
N_VERIFICATION	VARCHAR2(1000)	Yes	-	-
ID_METHOD_USED_2	VARCHAR2(1000)	Yes	-	-
DESC_MODEL_EVAL	VARCHAR2(4000)	Yes	-	-
DOC_MODEL_EVAL	VARCHAR2(1000)	Yes	-	-
RES_MODEL_EVAL_PAPER	VARCHAR2(4000)	Yes	-	-

RES_MODEL_EVAL_ADD	VARCHAR2(4000)	Yes	-	-
SENS_ANALYSIS	NUMBER	Yes	-	-
UNCERT_ANALYSIS	NUMBER	Yes	-	-
CALIBRATION	NUMBER	Yes	-	-
N_SENS_ANALYSIS	VARCHAR2(1000)	Yes	-	-
N_UNCERT_ANALYSIS	VARCHAR2(1000)	Yes	-	-
N_CALIBRATION	VARCHAR2(1000)	Yes	-	-
ID_METHOD_USED_AN	VARCHAR2(1000)	Yes	-	-
ID_METHOD_USED_AN_2	VARCHAR2(1000)	Yes	-	-
ID_METHOD_USED_AN_3	VARCHAR2(1000)	Yes	-	-
DESC_MODEL_EVAL_2	VARCHAR2(4000)	Yes	-	-
DOC_MODEL_EVAL_2	VARCHAR2(1000)	Yes	-	-
RES_MODEL_EVAL_PAPER_2	VARCHAR2(4000)	Yes	-	-
RES_MODEL_EVAL_ADD_2	VARCHAR2(4000)	Yes	-	-
RESEARCH	NUMBER	Yes	-	-
EDUCATION	NUMBER	Yes	-	-
SIMULATION	NUMBER	Yes	-	-
PREDICTION	NUMBER	Yes	-	-
DECISION_SUPPORT	NUMBER	Yes	-	-
WARNING	NUMBER	Yes	-	-
PRECISION_FARMING	NUMBER	Yes	-	-
EXPERT_SYSTEM	NUMBER	Yes	-	-
DATABASE	NUMBER	Yes	-	-
MAIN_OTHER	NUMBER	Yes	-	-
MAIN_OTHER_TXT	VARCHAR2(1000)	Yes	-	-
CURR_LIMITATION	VARCHAR2(4000)	Yes	-	-
FUTURE_DIRECTION	VARCHAR2(4000)	Yes	-	-
SUGGESTION_MAIN	VARCHAR2(4000)	Yes	-	-
ID_MEAS_TIME_4	VARCHAR2(1000)	Yes	-	-
INPUT_TEMP_EXT_WEAT	VARCHAR2(4000)	Yes	-	-
ID_MEAS_TIME_5	VARCHAR2(4000)	Yes	-	-
INPUT_TEMP_EXT_PEST	VARCHAR2(4000)	Yes	-	-
ID_MEAS_TIME_6	VARCHAR2(4000)	Yes	-	-
INPUT_TEMP_EXT_CROP	VARCHAR2(4000)	Yes	-	-
CALC_VAR_PEST	VARCHAR2(1000)	Yes	-	-
CALC_VAR_CROP	VARCHAR2(1000)	Yes	-	-
OUTPUT_DESC	VARCHAR2(4000)	Yes	-	-
ID_MEAS_TIME_7	VARCHAR2(4000)	Yes	-	-
OUTPUT_TEMP_EXT	VARCHAR2(4000)	Yes	-	-
OTH_CALC_VARS	VARCHAR2(4000)	Yes	-	-
PEST_OUTPUT	NUMBER	Yes	-	-
ID_PEST_OUTPUT	VARCHAR2(100)	Yes	-	-
LOSSES_OUTPUT	NUMBER	Yes	-	-
ID_LOSSES_OUTPUT	VARCHAR2(100)	Yes	-	-
ID_MEAS_PARAMETERS_PEST	VARCHAR2(100)	Yes	-	-
ID_MEAS_PARAMETERS_CROP	VARCHAR2(100)	Yes	-	-
MEAS_VAR_TXT	VARCHAR2(4000)	Yes	-	-
MEAS_TIME_TXT	VARCHAR2(4000)	Yes	-	-
MEAS_TIME_TXT_2	VARCHAR2(4000)	Yes	-	-
MEAS_TIME_TXT_3	VARCHAR2(4000)	Yes	-	-
MEAS_TIME_TXT_4	VARCHAR2(4000)	Yes	-	-
MEAS_TIME_TXT_5	VARCHAR2(4000)	Yes	-	-

MEAS_TIME_TXT_6	VARCHAR2(4000)	Yes	-	-
MEAS_TIME_TXT_7	VARCHAR2(4000)	Yes	-	-
CALC_VAR_TXT	VARCHAR2(4000)	Yes	-	-
PEST_OUTPUT_TXT	VARCHAR2(4000)	Yes	-	-
LOSSES_OUTPUT_TXT	VARCHAR2(4000)	Yes	-	-
METHOD_USED_TXT	VARCHAR2(4000)	Yes	-	-
METHOD_USED_TXT_2	VARCHAR2(4000)	Yes	-	-
METHOD_USED_AN_TXT	VARCHAR2(4000)	Yes	-	-
METHOD_USED_AN_TXT_2	VARCHAR2(4000)	Yes	-	-
METHOD_USED_AN_TXT_3	VARCHAR2(4000)	Yes	-	-
SENS_LOC_TXT	VARCHAR2(4000)	Yes	-	-
PEST_VAR_TXT	VARCHAR2(4000)	Yes	-	-
MEAS_PARAMETERS_PEST_TXT	VARCHAR2(4000)	Yes	-	-
HOST_VAR_TXT	VARCHAR2(4000)	Yes	-	-
MEAS_PARAMETERS_CROP_TXT	VARCHAR2(4000)	Yes	-	-

Annex 2.15
bibliographic search_CAB vs AGRIS

Disease	Key Words	CAB (No. of records)	AGRIS (No. of records)	No. of records in AGRIS only
1. Bacterial leaf streak	(“Xanthomonas translucens” OR “bacterial leaf streak”) AND wheat AND (model OR simulation OR prediction OR forecast)	2	0	0
2. Powdery mildew	(“blumeria graminis” OR “erysiphe graminis” OR “powdery mildew”) AND wheat AND (model OR simulation OR prediction OR forecast)	118	0	0
3. Leaf rust	("brown rust" OR "puccinia recondita") AND wheat AND (model OR simulation OR prediction OR forecast)	137	40	19
4. Leaf and glume blotch	(“septoria tritici” OR “mycosphaerella graminicola” OR “septoria nodorum” OR “stagonospora nodorum” OR “leaf blotch” OR “glume blotch”) AND wheat AND (model OR simulation OR prediction OR forecast)	130	11	4
5. Karnal bunt	(“tilletia indica” OR “neovossia indica” OR “karnal bunt”) AND wheat AND (model OR simulation OR prediction OR forecast)	21	1	1
6. FHB and mycotoxins				
6.1. Fusarium head blight	(“gibberella zeae” OR “fusarium graminearum” OR “fusarium head blight” OR “wheat scab”) AND wheat AND (model OR simulation OR prediction OR forecast)	83	1	1
6.2. Fusarium spp. and related mycotoxins	mycotoxin AND wheat AND (fusarium OR gibberella) AND (model OR simulation OR prediction OR forecast)	19	1	1
7. Ergot	(claviceps OR “claviceps purpurea” OR ergot OR “sphacelia segetum” OR “sclerotium clavus” OR “sphaeria purpurea”) AND wheat AND (model OR simulation OR prediction OR forecast)	2	0	0
8. Barley yellow dwarf virus	“barley yellow dwarf virus” AND wheat AND (model OR simulation OR prediction OR forecast)	17	1	0

Annex 2.16
bibliographic search_Google

Disease	**Key Words** (used in Google)	**CAB** (No. of records)	**Google** (No. of records)	**Google** (filter pdf files) (No. of records)	**Scholar Google** (No. of records)	**Google** (+ software) (No. of records)	**Google** (disease name + wheat+ software”) (No. of records)
1. Bacterial leaf streak	“bacterial leaf streak” wheat “model | simulation | prediction | forecast”	2	1290	228	129	210	670
2. Powdery mildew	“powdery mildew” wheat “model | simulation | prediction | forecast”	118	117000	8400	5900	29700	18900
3. Leaf rust	“brown rust” wheat “model | simulation | prediction | forecast”	137	23300	1040	719	512	2250
4. Leaf and glume blotch	“leaf blotch” wheat “model | simulation | prediction | forecast”	130	5330	1510	1010	1570	3430
5. Karnal bunt	“karnal bunt” wheat “model | simulation | prediction | forecast”	21	13500	1540	554	1890	4120
6. FHB and mycotoxins							
6.1. Fusarium head blight	“fusarium head blight” wheat “model | simulation | prediction | forecast”	83	12900	3500	1970	4260	10400
6.2. Fusarium spp. and related mycotoxins	mycotoxin wheat fusarium “model | simulation | prediction | forecast”	19	70000	6710	3830	8120	13100
7. Ergot	ergot wheat “model | simulation | prediction | forecast”	2	13100	2940	1820	7710	8650
8. Barley yellow dwarf virus	“barley yellow dwarf virus” wheat “model | simulation | prediction | forecast”	17	5980	1670	1440	2250	5000

Annex 3.1
Bibliographic search_EPPO_A1

Bacteria and phytoplasmas	
Keywords	**No. records**
(Citrus huanglongbing OR citrus greening OR Liberibacter asiaticum OR Liberibacter africanum OR Citrus greening bacterium OR vein phloem degeneration) AND (model OR simulation OR prediction OR forecast)	2
(Phytoplasma ulmi OR Elm phloem necrosis OR elm yellows) AND (model OR simulation OR prediction OR forecast)	1
(Palm lethal yellowing phytoplasma OR Coconut lethal yellowing pathogen) AND (model OR simulation OR prediction OR forecast)	0
(Peach rosette phytoplasma OR Peach rosette) AND (model OR simulation OR prediction OR forecast)	0
(Peach yellows phytoplasma OR Peach little peach MLO OR Peach red suture MLO OR Peach yellows OR little peach disease OR red suture disease) AND (model OR simulation OR prediction OR forecast)	0
(Potato purple-top wilt phytoplasma OR Aster yellows phytoplasma OR Apical leafroll OR blue stem OR bunch top OR haywire OR late breaking OR purple dwarf OR yellow top) AND (model OR simulation OR prediction OR forecast)	2
(Peach X-disease phytoplasma OR Peach western X MLO OR Peach yellow leafroll MLO OR Peach X-disease OR cherry buckskin OR peach yellow leafroll OR leaf casting yellows) AND (model OR simulation OR prediction OR forecast)	0
((Xanthomonas axonopodis AND citri) OR (Xanthomonas campestris AND citri) OR Pseudomonas citri OR Xanthomonas citri OR (Xanthomonas citri AND aurantifoliae) OR (Xanthomonas campestris AND aurantifolii) OR Citrus canker OR bacterial canker of citrus OR citrus bacterial canker OR Asiatic canker OR canker A OR cancrosis A OR South American canker OR false canker OR canker B OR cancrosis B OR Mexican lime cancrosis OR canker C OR citrus bacteriosis OR canker D) AND (model OR simulation OR prediction OR forecast)	26
((Xanthomonas oryzae AND oryzae) OR Pseudomonas oryzae OR (Xanthomonas campestris AND oryzae) OR Xanthomonas itoana OR Xanthomonas kresek OR Xanthomonas oryzae OR (Xanthomonas translucens AND oryzae) OR Bacterial leaf blight OR Kresek disease) AND (model OR simulation OR prediction OR forecast)	49
((Xanthomonas oryzae AND oryzicola) OR (Xanthomonas campestris AND oryzicola) OR Xanthomonas oryzicola OR (Xanthomonas translucens AND oryzicola) OR Bacterial leaf streak) AND (model OR simulation OR prediction OR forecast)	6
(Xylella fastidiosa OR Pierce's disease OR California vine disease OR (Anaheim disease AND grapevine) OR (leaf scorch AND almond) OR (dwarf AND lucerne) OR (phony disease AND peach) OR (leaf scald AND plum) OR (leaf scorch AND (elm OR oak OR plane OR mulberry OR maple)) OR (variegated chlorosis AND citrus)) AND (model OR simulation OR prediction OR forecast)	28
Fungi	
Keywords	**No. records**
(Alternaria mali or Alternaria blotch) AND (model OR simulation OR prediction OR forecast)	5

(Anisogramma anomala OR Apioporthe anomala OR Cryptosporella anomala OR Eastern filbert blight) AND (model OR simulation OR prediction OR forecast)	1
(Apiosporina morbosa OR Sphaeria morbosa OR Dibotryon morbosum OR Otthia morbosa OR Plowrightia morbosa OR Cucurbitaria morbosa OR Black knot) AND (model OR simulation OR prediction OR forecast)	1
(Atropellis OR Atropellis piniphila OR Atropellis pinicola OR Branch and trunk canker of pine OR twig blight) AND (model OR simulation OR prediction OR forecast)	1
(Ceratocystis fagacearum OR Chalara quercina OR Oak wilt) AND (model OR simulation OR prediction OR forecast)	2
(Chrysomyxa arctostaphyli OR Melampsoropsis arctostaphyli OR Peridermium coloradense OR Common yellow witches' broom rust OR spruce broom rust) AND (model OR simulation OR prediction OR forecast)	0
(Cronartium coleosporioides OR Peridermium stalactiforme OR Stalactiform blister rust) AND (model OR simulation OR prediction OR forecast)	0
(Cronartium comandrae OR Peridermium pyriforme OR Comandra blister rust) AND (model OR simulation OR prediction OR forecast)	1
(Cronartium comptoniae OR Peridermium comptoniae OR Sweetfern blister rust) AND (model OR simulation OR prediction OR forecast)	0
(Cronartium fusiforme OR Cronartium quercuum OR Peridermium fusiforme OR Southern fusiform rust) AND (model OR simulation OR prediction OR forecast)	36
(Cronartium himalayense OR Peridermium himalayense OR Chir pine blister rust) AND (model OR simulation OR prediction OR forecast)	0
(Peridermium cerebrum OR Eastern pine gall rust) AND (model OR simulation OR prediction OR forecast)	0
(Davidiella populorum OR Mycosphaerella populorum OR Septoria musiva OR Septoria canker of poplar) AND (model OR simulation OR prediction OR forecast)	3
(Diaporthe vaccinii OR Phomopsis vaccinii OR Phomopsis canker and dieback OR twig blight OR fruit rot OR storage rot OR viscid rot) AND (model OR simulation OR prediction OR forecast)	26
(Endocronartium harknessii OR Cronartium harknessii OR Peridermium OR Western gall rust OR pine-pine gall rust) AND (model OR simulation OR prediction OR forecast)	13
(Gibberella circinata OR Fusarium circinatum OR Fusarium subglutinans OR Fusarium lateritium OR pitch canker of pine) AND (model OR simulation OR prediction OR forecast)	6
(Guignardia citricarpa OR Phyllosticta citricarpa OR Phoma citricarpa OR Phyllostictina citricarpa OR Leptodothiorella OR Black spot OR hard spot OR shot-hole OR freckle spot OR virulent spot OR speckled blotch of citrus) AND (model OR simulation OR prediction OR forecast)	24
(Gymnosporangium clavipes OR Gymnosporangium germinale OR Podisoma gymnosporangium-clavipes OR Caeoma germinale OR Roestelia aurantiaca OR Quince rust) AND (model OR simulation OR prediction OR forecast)	0
(Gymnosporangium globosum OR (Gymnosporangium fuscum AND globosum) OR American hawthorn rust) AND (model	0

OR simulation OR prediction OR forecast)	
(Gymnosporangium juniperi-virginianae OR Gymnosporangium macropus OR Gymnosporangium virginianum OR Aecidium pyrolatum OR Roestelia pyrata OR Cedar apple rust OR American apple rust) AND (model OR simulation OR prediction OR forecast)	6
(Gymnosporangium yamadae OR Japanese apple rust) AND (model OR simulation OR prediction OR forecast)	0
(Melampsora farlowii OR Chrysomyxa farlowii OR Necium farlowii OR Hemlock rust) AND (model OR simulation OR prediction OR forecast)	0
(Mycosphaerella gibsonii OR Cercospora pini-densiflorae OR Cercoseptoria pini-densiflorae OR Pseudocercospora pini-densiflorae OR Brown needle blight of pine OR cercospora pine blight) AND (model OR simulation OR prediction OR forecast)	1
(Mycosphaerella laricis-leptolepidis OR Phoma yano-kubotae OR Phyllosticta laricis OR Needle cast of Japanese larch) AND (model OR simulation OR prediction OR forecast)	0
(Ophiostoma wageneri OR Ceratocystis wageneri OR (Leptographium wageneri AND ponderosum) OR (Verticicladiella wageneri AND ponderosa) OR Black stain root disease) AND (model OR simulation OR prediction OR forecast)	3
(Phaeoramularia angolensis OR Cercospora angolensis OR Citrus leaf spot OR citrus fruit spot) AND (model OR simulation OR prediction OR forecast)	1
(Phellinus weirii OR Inonotus weirii OR Poria weirii OR Fomitiporia weirii OR Laminated butt rot OR yellow ring rot) AND (model OR simulation OR prediction OR forecast)	12
(Phoma andina OR Black potato blight OR Phoma potato leaf spot) AND (model OR simulation OR prediction OR forecast)	0
(Phyllosticta solitaria OR Apple blotch) AND (model OR simulation OR prediction OR forecast)	0
(Phymatotrichopsis OR Phymatotrichum omnivorum OR Ozonium omnivorum OR Ozonium auricomum OR Phymatotrichum root rot OR Texas root rot) AND (model OR simulation OR prediction OR forecast)	8
(Phytophthora lateralis OR root rot of Chamaecyparis) AND (model OR simulation OR prediction OR forecast)	1
(Puccinia hemerocallidis OR Puccinia funkiae OR rust of daylily) AND (model OR simulation OR prediction OR forecast)	1
(Puccinia pittieriana OR Common potato rust) AND (model OR simulation OR prediction OR forecast)	0
(Septoria lycopersici OR Septoria leafspot OR annular leafspot) AND (model OR simulation OR prediction OR forecast)	3
(Sirococcus clavigignenti-juglandacearum OR canker of butternut) AND (model OR simulation OR prediction OR forecast)	0
(Stegophora ulmea OR Gnomonia ulmea OR Sphaeria ulmea OR Dothidella ulmea OR Lambro ulmea OR Gloeosporium ulmeum OR Gloeosporium ulmicolum OR Cylindrosporella ulmea OR Asteroma ulmeum OR black spot of elm OR twig blight OR elm leaf scab OR elm leaf spot) AND (model OR simulation OR prediction OR forecast)	1
(Thecaphora solani OR Angiosorus solani OR Potato smut) AND (model OR simulation OR prediction OR forecast)	0
Viruses and virus-like organisms	
Keywords	**No. records**
(Plum American line pattern ilarvirus OR American plum line pattern virus OR Plum line pattern virus OR Plum line pattern	0

OR banded chlorosis of oriental flowering cherry OR APLPV) AND (model OR simulation OR prediction OR forecast)	
(Potato Andean mottle comovirus OR Potato mottle virus OR Andean potato mottle virus OR APMoV) AND (model OR simulation OR prediction OR forecast)	1
(Bean golden mosaic bigeminivirus OR BGMV OR Bean golden mosaic OR bean golden yellow mosaic) AND (model OR simulation OR prediction OR forecast)	3
(Cherry rasp leaf nepovirus OR Flat apple virus OR CRLV OR American cherry rasp leaf OR flat apple) AND (model OR simulation OR prediction OR forecast)	0
(Chrysanthemum stem necrosis virus OR CSNV) AND (model OR simulation OR prediction OR forecast)	1
(Citrus blight disease OR Young tree decline OR sandhill decline OR roadside decline OR rough lemon decline) AND (model OR simulation OR prediction OR forecast)	2
(Citrus leprosis rhabdovirus OR CiLV) AND (model OR simulation OR prediction OR forecast)	1
(Citrus mosaic badnavirus OR CiMV) AND (model OR simulation OR prediction OR forecast)	0
(Citrus tatter leaf capillovirus OR Citrange stunt virus OR Bud-union crease OR yellow ring) AND (model OR simulation OR prediction OR forecast)	1
(Coconut cadang-cadang viroid OR CCCVd OR Cadang-cadang disease) AND (model OR simulation OR prediction OR forecast)	1
(Eggplant mosaic virus OR Potato Andean latent tymovirus OR Potato latent virus OR Andean latent virus OR Andean potato latent virus OR APLV) AND (model OR simulation OR prediction OR forecast)	1
(Lettuce infectious yellows closterovirus OR LIYV) AND (model OR simulation OR prediction OR forecast)	1
(Peach mosaic ?closterovirus OR Peach mosaic virus OR PcMV) AND (model OR simulation OR prediction OR forecast)	6
(Peach rosette mosaic nepovirus OR PRMV) AND (model OR simulation OR prediction OR forecast)	0
(Potato black ringspot nepovirus OR Tobacco ringspot nepovirus OR potato calico strain OR Tobacco ringspot nepovirus OR Andean potato calico strain OR PBRSV) AND (model OR simulation OR prediction OR forecast)	5
(Potato T trichovirus OR Potato T capillovirus OR Potato virus T OR PVT) AND (model OR simulation OR prediction OR forecast)	8
(Potato yellow dwarf nucleorhabdovirus OR PYDV) AND (model OR simulation OR prediction OR forecast)	0
(Potato yellow vein disease OR Potato yellow vein 'virus') AND (model OR simulation OR prediction OR forecast)	1
(Potato yellowing alfamovirus OR PYV) AND (model OR simulation OR prediction OR forecast)	6
(Raspberry leaf curl 'luteovirus' OR RLCV OR Raspberry curl OR American raspberry leaf curl) AND (model OR simulation OR prediction OR forecast)	0
(Squash leaf curl bigeminivirus OR Watermelon curly mottle virus OR Melon leaf curl virus OR SLCV) AND (model OR simulation OR prediction OR forecast)	5
(Strawberry latent C 'rhabdovirus') AND (model OR simulation OR prediction OR forecast)	0
(Tomato mottle bigeminivirus OR ToMoV) AND (model OR simulation OR prediction OR forecast)	2

(Watermelon silver mottle tospovirus OR Watermelon silver mottle virus OR Watermelon silvery mottle virus OR Watermelon tospovirus OR TSWV-W OR WSMV OR Watermelon silver mottle disease) AND (model OR simulation OR prediction OR forecast)	4
Insects and mites	
Keywords	**No. records**
(Acleris variana OR Teras variana OR Peronea variana OR Peronea angusana Fernald OR Eastern blackheaded budworm) AND (model OR simulation OR prediction OR forecast)	1
(Acleris gloverana OR Western blackheaded budworm) AND (model OR simulation OR prediction OR forecast)	0
(Agrilus planipennis OR Agrilus feretrius OR Agrilus marcopoli OR emerald ash borer) AND (model OR simulation OR prediction OR forecast)	3
(Aleurocanthus spiniferus OR Aleurodes spinifera OR Aleurodes citricola OR Aleurocanthus citricolus OR Aleurocanthus rosae OR Orange spiny whitefly OR spiny blackfly) AND (model OR simulation OR prediction OR forecast)	2
(Aleurocanthus woglumi OR Aleurocanthus punjabensis OR Citrus blackfly) AND (model OR simulation OR prediction OR forecast)	1
(Anastrepha fraterculus OR Acrotoxa fraterculus OR Anastrepha braziliensis OR Anastrepha peruviana OR Anastrepha soluta OR Anthomyia frutalis OR Dacus fraterculus OR Tephritis mellea OR Trypeta fraterculus OR Trypeta unicolor OR South American fruit fly) AND (model OR simulation OR prediction OR forecast)	1
(Anastrepha ludens OR Acrotoxa ludens OR Trypeta ludens OR Mexican fruit fly) AND (model OR simulation OR prediction OR forecast)	10
(Anastrepha obliqua OR Acrotoxa obliqua OR Anastrepha fraterculus var. mombinpraeoptans OR Anastrepha mombinpraeoptans OR Anastrepha trinidadensis OR Tephritis obliqua OR Trypeta obliqua OR West Indian fruit fly OR Antillean fruit fly) AND (model OR simulation OR prediction OR forecast)	4
(Anastrepha suspensa OR Acrotoxa suspensa OR Anastrepha longimacula OR Anastrepha unipuncta OR Trypeta suspensa OR Caribbean fruit fly OR greater Antillean fruit fly) AND (model OR simulation OR prediction OR forecast)	6
(Anoplophora glabripennis OR Asian long-horn beetle OR Basicosta white-spotted longicorn beetle OR Starry sky beetle) AND (model OR simulation OR prediction OR forecast)	8
(Anthonomus bisignifer OR Anthonomus bisignatus OR Anthonomus signatus OR Minyrus japonicus OR Minyrus albopilosus OR Strawberry weevil OR strawberry blossom weevil) AND (model OR simulation OR prediction OR forecast)	4
(Anthonomus eugenii OR Anthonomus aeneotinctus OR Pepper weevil) AND (model OR simulation OR prediction OR forecast)	0
(Anthonomus grandis OR Boll weevil) AND (model OR simulation OR prediction OR forecast)	63
(Anthonomus signatus OR Anthonomus bisignatus OR Anthonomus pallidus OR Anthonomus scutellatus OR Strawberry weevil OR strawberry bud weevil) AND (model OR simulation OR prediction OR forecast)	1
(Pseudopityophthorus minutissimus OR Crypturgus minutissimus OR Oak bark beetle OR Pseudopityophthorus pruinosus OR	0

Pityophthorus pruinosus OR Pityophthorus tomentosus OR Pityophthorus querciperda OR Pseudopityophthorus pulvereus OR Pseudopityophthorus tropicalis OR Pseudopityophthorus convexus OR Arrhenodes minutus) AND (model OR simulation OR prediction OR forecast)	
(Bactrocera cucumis OR Austrodacus cucumis OR Dacus cucumis OR Dacus tryoni var. cucumis OR Cucumber fly) AND (model OR simulation OR prediction OR forecast)	1
(Bactrocera cucurbitae OR Chaetodacus cucurbitae OR Dacus cucurbitae Coquillett OR Strumeta cucurbitae OR Zeugodacus cucurbitae OR Melon fly OR melon fruit fly) AND (model OR simulation OR prediction OR forecast)	21
(Bactrocera dorsalis OR Chaetodacus ferrugineus OR Chaetodacus ferrugineus dorsalis OR Chaetodacus ferrugineus var. okinawanus Shiraki OR Dacus dorsalis OR Strumeta dorsalis OR Oriental fruit fly) AND (model OR simulation OR prediction OR forecast)	34
(Bactrocera carambolae OR Bactrocera sp. A OR Carambola fruit fly) AND (model OR simulation OR prediction OR forecast)	3
(Bactrocera caryeae OR Dacus caryeae) AND (model OR simulation OR prediction OR forecast)	0
(Bactrocera kandiensis OR Bactrocera sp. D) AND (model OR simulation OR prediction OR forecast)	0
(Bactrocera occipitalis OR Chaetodacus ferrugineus var. occipitalis OR Dacus occipitalis) AND (model OR simulation OR prediction OR forecast)	0
(Bactrocera papayae OR Bactrocera sp. B) AND (model OR simulation OR prediction OR forecast)	5
(Bactrocera philippinensis OR Bactrocera sp. C) AND (model OR simulation OR prediction OR forecast)	1
(Bactrocera pyrifoliae) AND (model OR simulation OR prediction OR forecast)	0
(Bactrocera minax OR Polistomimetes minax OR Callantra minax OR Bactrocera citri OR Mellesis citri OR Dacus citri OR Tetradacus citri OR Chinese citrus fly) AND (model OR simulation OR prediction OR forecast)	0
(Bactrocera tryoni OR Chaetodacus tryoni OR Dacus ferrugineus tryoni OR Dacus tryoni OR Strumeta tryoni OR Tephritis tryoni OR Queensland fruit fly) AND (model OR simulation OR prediction OR forecast)	31
(Bactrocera tsuneonis OR Dacus tsuneonis OR Dacus cheni OR Japanese orange fly) AND (model OR simulation OR prediction OR forecast)	0
(Bactrocera zonata OR Dacus zonatus OR Dasyneura zonata OR Rivellia persicae OR peach fruit fly OR guava fruit fly) AND (model OR simulation OR prediction OR forecast)	1
(Blitopertha orientalis OR Anomala orientalis OR Oriental beetle) AND (model OR simulation OR prediction OR forecast)	3
(Carneocephala fulgida OR Draeculacephala minerva OR Graphocephala atropunctata OR Homalodisca coagulata) AND (model OR simulation OR prediction OR forecast)	19
(Ceratitis rosa OR Pterandrus rosa OR Natal fruit fly OR Natal fly) AND (model OR simulation OR prediction OR forecast)	3
(Choristoneura conflictana OR Archips conflictana OR Tortrix conflictana OR Heterognomon conflictana OR Cacoecia conflictana OR Large aspen tortrix) AND (model OR simulation OR prediction OR forecast)	2
(Choristoneura fumiferana OR Tortrix fumiferana OR Harmologa fumiferana OR Cacoecia fumiferana OR Archips fumiferana OR Choristoneura fumiferana OR Tortrix nigridia OR Lozotaenia retiniana OR Archips retiniana OR Cacoecia retiniana OR	204

Choristoneura retiniana OR Choristoneura lambertiana lindseyana OR Spruce budworm) AND (model OR simulation OR prediction OR forecast)	
(Choristoneura occidentalis OR Western spruce budworm) AND (model OR simulation OR prediction OR forecast)	56
(Choristoneura rosaceana OR Loxotaenia rosaceana OR Tortrix rosaceana OR Cacoecia rosaceana OR Archips rosaceana OR Teras vicariana OR Tortrix gossypiana OR Oblique-banded leafroller) AND (model OR simulation OR prediction OR forecast)	12
(Conotrachelus nenuphar OR Plum curculio OR plum weevil) AND (model OR simulation OR prediction OR forecast)	10
(Cydia packardi OR Grapholitha packardi OR Steganoptycha pyricolana OR Enarmonia packardi OR Enarmonia pyricolana OR Laspeyresia packardi OR Laspeyresia pyricolana OR Cherry fruitworm) AND (model OR simulation OR prediction OR forecast)	0
(Cydia prunivora OR Grapholitha prunivora OR Enarmonia prunivora OR Semasia prunivora OR Laspeyresia prunivora OR Lesser appleworm OR plum moth) AND (model OR simulation OR prediction OR forecast)	0
(Dacus ciliatus OR Dacus appoxanthus var. decolor OR Dacus brevistylus OR Dacus insistens OR Dacus sigmoides OR Didacus ciliatus OR Leptoxyda ciliata OR Tridacus mallyi OR Ethiopian fruit fly OR lesser pumpkin fly OR cucurbit fly) AND (model OR simulation OR prediction OR forecast)	2
(Dendroctonus adjunctus OR Dendroctonus convexifrons OR Round-headed pine beetle) AND (model OR simulation OR prediction OR forecast)	1
(Dendroctonus brevicomis OR Dendroctonus barberi OR Western pine beetle) AND (model OR simulation OR prediction OR forecast)	6
(Dendroctonus frontalis OR Dendroctonus arizonicus OR Southern pine beetle) AND (model OR simulation OR prediction OR forecast)	95
(Dendroctonus ponderosae OR Dendroctonus monticolae OR Mountain pine beetle OR Black Hills beetle) AND (model OR simulation OR prediction OR forecast)	144
(Dendroctonus pseudotsugae OR Douglas fir beetle) AND (model OR simulation OR prediction OR forecast)	13
(Dendroctonus rufipennis OR Dendroctonus borealis OR Dendroctonus engelmanni OR Dendroctonus piceaperda OR Dendroctonus similis OR Hylurgus rufipennis OR Spruce beetle OR Engelmann spruce beetle OR red-winged pine beetle) AND (model OR simulation OR prediction OR forecast)	23
(Diabrotica barberi OR Diabrotica longicornis barberi OR Northern corn rootworm) AND (model OR simulation OR prediction OR forecast)	13
(Diabrotica speciosa OR San Antonio beetle) AND (model OR simulation OR prediction OR forecast)	2
(Diabrotica undecimpunctata OR Diabrotica soror OR spotted cucumber beetle) AND (model OR simulation OR prediction OR forecast)	10
(Diaphorina citri OR Citrus psyllid) AND (model OR simulation OR prediction OR forecast)	9
(Dryocoetes confusus OR Dendroctonus abietis OR Western balsam bark beetle) AND (model OR simulation OR prediction OR forecast)	1

(Epitrix cucumeris OR potato flea beetle) AND (model OR simulation OR prediction OR forecast)	0
(Epitrix tuberis OR Tuber flea beetle) AND (model OR simulation OR prediction OR forecast)	0
(Gnathotrichus sulcatus OR Cryphalus sulcatus OR Gnathotrichus aciculatus OR Western hemlock wood stainer) AND (model OR simulation OR prediction OR forecast)	1
(Gonipterus gibberus OR Dacnirotatus bruchi OR eucalyptus snout beetle OR eucalyptus weevil OR gum tree weevil) AND (model OR simulation OR prediction OR forecast)	2
(Helicoverpa zea OR Heliothis zea OR Bombyx obsoleta OR Phalaena zea OR Heliothis umbrosus OR American bollworm OR corn earworm OR tomato fruitworm OR New World bollworm) AND (model OR simulation OR prediction OR forecast)	120
(Heteronychus arator OR Scarabaeus arator OR Heteronychus sanctaehelenae OR black maize beetle OR African black beetle OR black beetle) AND (model OR simulation OR prediction OR forecast)	3
(Ips calligraphus OR Bostrichus calligraphus OR Ips ponderosae OR Ips interstitialis OR Coarse writing engraver OR six-spined ips OR six-spined engraver beetle) AND (model OR simulation OR prediction OR forecast)	4
(Ips confusus OR Tomicus confusus OR Piñon ips) AND (model OR simulation OR prediction OR forecast)	3
(Ips paraconfusus OR California five-spined engraver OR California five-spined ips) AND (model OR simulation OR prediction OR forecast)	4
(Ips grandicollis OR Ips chagnoni OR Ips cloudcrofti OR Tomicus grandicollis OR Southern pine engraver) AND (model OR simulation OR prediction OR forecast)	4
(Ips lecontei OR Arizona five-spined engraver OR Arizona five-spined ips) AND (model OR simulation OR prediction OR forecast)	1
(Ips pini OR Bostrichus pini OR Ips laticollis OR Ips oregonis OR Eastern pine engraver OR pine engraver beetle) AND (model OR simulation OR prediction OR forecast)	16
(Ips plastographus OR Tomicus plastographus OR California pine engraver) AND (model OR simulation OR prediction OR forecast)	0
(Listronotus bonariensis OR Hyperodes bonariensis OR Argentine stem weevil OR wheat stem weevil) AND (model OR simulation OR prediction OR forecast)	8
(Maconellicoccus hirsutus OR Phenacoccus hirsutus OR pink hibiscus mealybug OR pink mealybug OR hibiscus mealybug) AND (model OR simulation OR prediction OR forecast)	6
(Malacosoma americanum OR Eastern tent caterpillar OR orchard tent caterpillar OR apple tent caterpillar) AND (model OR simulation OR prediction OR forecast)	0
(Malacosoma disstria OR Forest tent caterpillar) AND (model OR simulation OR prediction OR forecast)	16
(Margarodes prieskaensis OR Sphaeraspis prieskaensis OR Ground pearls OR margarodes) AND (model OR simulation OR prediction OR forecast)	0
(Margarodes vitis OR Coccionella vitis OR Margarodes vitium OR Sphaeraspis vitis OR Ground pearls OR margarodes) AND (model OR simulation OR prediction OR forecast)	0

(Margarodes vredendalensis OR Ground pearls OR margarodes) AND (model OR simulation OR prediction OR forecast)	0
(Melanotus communis OR Elater communis OR common wireworm OR corn wireworm OR community wireworm) AND (model OR simulation OR prediction OR forecast)	1
(Monochamus alternatus OR Monochamus carolinensis OR Monochamus OR Monochamus mutator OR Monochamus nitens OR Monochamus notatus OR Monochamus obtusus OR Monochamus saltuarius OR Monochamus scutellatus OR Monochamus titillator) AND (model OR simulation OR prediction OR forecast)	29
(Myndus crudus OR Myndus cocois OR Haplaxius crudus OR Pallid cane leafhopper) AND (model OR simulation OR prediction OR forecast)	0
(Naupactus leucoloma OR Graphognathus leucoloma OR Pantomorus leucoloma OR white-fringed weevil OR white-fringed beetle) AND (model OR simulation OR prediction OR forecast)	3
(Amauromyza maculosa OR Agromyza guaranitica OR Chrysanthemum leaf miner OR burdock leaf miner) AND (model OR simulation OR prediction OR forecast)	1
(Oligonychus perditus OR Oligonychus chamaecyparisae OR Byakushin-hadani) AND (model OR simulation OR prediction OR forecast)	0
(Orgyia pseudotsugata OR Douglas-fir tussock moth) AND (model OR simulation OR prediction OR forecast)	28
(Limonius californicus OR Cardiophorus californicus OR Pheletes californicus OR sugarbeet wireworm) AND (model OR simulation OR prediction OR forecast)	1
(Pissodes nemorensis OR Pissodes approximatus OR Pissodes canadensis OR Pissodes deodarae OR Northern pine weevil OR deodar weevil) AND (model OR simulation OR prediction OR forecast)	0
(Pissodes strobi OR Pissodes sitchensis OR Pissodes engelmanni OR White pine weevil OR Sitka spruce weevil) AND (model OR simulation OR prediction OR forecast)	13
(Pissodes terminalis OR Lodgepole terminal weevil) AND (model OR simulation OR prediction OR forecast)	0
(Premnotrypes latithorax OR Premnotrypes suturicallus OR Premnotrypes vorax OR Andean potato weevil) AND (model OR simulation OR prediction OR forecast)	0
(Rhagoletis fausta OR Rhagoletis intrudens OR Trypeta fausta OR Acidia fausta OR Black cherry fruit fly) AND (model OR simulation OR prediction OR forecast)	1
(Rhagoletis indifferens OR Rhagoletis cingulata OR Trypeta cingulata OR Eastern cherry fruit fly OR cherry fruit fly,) AND (model OR simulation OR prediction OR forecast)	16
(Rhagoletis mendax OR Blueberry maggot) AND (model OR simulation OR prediction OR forecast)	5
(Rhagoletis pomonella OR Trypeta pomonella OR Apple maggot OR apple maggot fly) AND (model OR simulation OR prediction OR forecast)	32
(Rhizoecus hibisci OR Ripersiella hibisci OR root mealybug) AND (model OR simulation OR prediction OR forecast)	0
(Rhynchophorus palmarum OR Calandra palmarum OR Cordyle barbirostris OR Cordyle palmarum OR Curculio palmarum OR Rhynchophorus cycadis OR Rhynchophorus depressus OR Rhynchophorus languinosus OR Taxonomic position OR palm	12

weevil OR palm-marrow weevil OR South American palm weevil) AND (model OR simulation OR prediction OR forecast)	
(Scaphoideus luteolus OR White-banded elm leafhopper) AND (model OR simulation OR prediction OR forecast)	0
(Scirtothrips aurantii OR Scirtothrips acaciae OR South African citrus thrips) AND (model OR simulation OR prediction OR forecast)	0
(Scirtothrips citri OR Euthrips citri OR California citrus thrips) AND (model OR simulation OR prediction OR forecast)	9
(Spodoptera eridania OR Laphygma eridania OR Prodenia eridania OR Xylomyges eridania OR Southern armyworm OR Semitropical armyworm) AND (model OR simulation OR prediction OR forecast)	3
(Spodoptera frugiperda OR Laphygma frugiperda OR Fall armyworm OR corn leafworm OR southern grassworm) AND (model OR simulation OR prediction OR forecast)	82
(Spodoptera littoralis OR Hadena littoralis OR Cotton leafworm OR Egyptian cottonworm OR Mediterranean brocade moth OR *Spodoptera litura* OR *Prodenia litura* OR Cotton leafworm OR tobacco cutworm) AND (model OR simulation OR prediction OR forecast)	87
(Sternochetus mangiferae OR Cryptorhynchus mangiferae OR Acryptorhynchus mangiferae OR Mango seed weevil OR mango weevil OR mango nut or stone weevil) AND (model OR simulation OR prediction OR forecast)	1
(Thrips palmi OR Thrips leucadophilus OR Thrips gossypicola OR Chloethrips aureus OR Thrips gracilis OR Palm thrips) AND (model OR simulation OR prediction OR forecast)	14
(Trioza erytreae OR Spanioza erytreae OR Trioza merwei OR Citrus psylla) AND (model OR simulation OR prediction OR forecast)	8
(Tuta absoluta OR Scrobipalpuloides absoluta OR Scrobipalpula absoluta OR Gnorimoschema absoluta OR Phthorimaea absoluta OR tomato borer OR South American tomato moth OR tomato leaf miner OR South American tomato pinworm) AND (model OR simulation OR prediction OR forecast)	4
(Unaspis citri OR Chionaspis citri OR Prontaspis citri OR Dinaspis veitchi OR Citrus snow scale OR white louse scale) AND (model OR simulation OR prediction OR forecast)	1
Nematodes	
Keywords	**No. records**
(Bursaphelenchus xylophilus OR Aphelenchoides xylophilus OR Bursaphelenchus lignicolus OR Pine wood nematode OR pine wilt disease) AND (model OR simulation OR prediction OR forecast)	28
(Nacobbus aberrans OR Anguillulina aberrans OR Nacobbus batatiformis OR Nacobbus serendipiticus OR Nacobbus serendipiticus bolivianus OR False root-knot nematode) AND (model OR simulation OR prediction OR forecast)	5
(Radopholus OR Radopholus similis citrus race OR Citrus spreading decline nematode) AND (model OR simulation OR prediction OR forecast)	15
(Xiphinema americanum OR Tylencholaimus americanus OR American dagger nematode OR Xiphinema bricolense OR Xiphinema californicum OR Xiphinema rivesi) AND (model OR simulation OR prediction OR forecast)	4

Annex 3.2
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Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
1861	M-LWPApple	Aldwinckle HS, Pearson RC, Seem RC, 1980. Infection periods of Gymnosporangium juniperi-virginianae on apple. Phytopathology, 70, 1070-1073.					Duration of leaf wetness period (LWP) required for light and severe infection of apple (Malus pumila 'Rome Beauty') seedings by basidiospores of Gymnosporangium juniperi-virginianae were determined experimentally at 2-32 C. Infection occurred from 2 C (light infection, LWP 24 hr) to 24 C (light infection, LWP 2 hr). The optimum temperatures for infection were 10-24 C (light infection, LWP 2-5 hr; severe infection, LWP 4-6 hr). Leaves 4, 6 and 8 days old generally bore more lesions than did 10- and 12-day-old leaves, wich bore very few lesions at low temperatures. Models developed to predict light and severe infection accounted for 98 and 97%, respectively, of the observed variation. The models were tested with data from LWP's monitored in the field for two yr and successfully predicted infection or no infection in 23 of 24 LWP's. The models, together with available information on requirements for teliospore germination and basidiospore formation, enable prediction of infection periods in the field, thus allowing efficient use of eradicant fungicides for the control of cedar apple rust.	
3121	M-WCFF_Phenol	AliNiazee MT, 1979. A computerized phenology model for predicting biological events of Rhagoletis indifferens (Diptera: Tephritidae). Can. Entomol. 111: 10, 1101-1109.					A phenology model based on a time-temperature relationship has been developed for the western cherry fruit fly, Rhagoletis indifferens Curran. The model predicts the occurrence of various biological events such as emergence levels, mating, oviposition, larval appearance, parasite activity, and pupation. These events are predicted as a function of summation of thermal units (TU) starting I March. For example, emergence begins at 462, oviposition at 541, hatch at 594, and pupation at 795 TU. The model was validated by actual field observations for a period of 3 years (1976-1978). Extended validation of first emergence was obtained from an entirely different cherry growing area, the Hood River Valley. The model could be a useful tool in integrated pest management program on cherries	
2222	M-MPB_PopMov	Aukema BH, Carroll AL, Zheng YB, Zhu J, Raffa KF, Moore RD, Stahl K, Taylor SW, 2008. Movement of outbreak populations of mountain pine beetle: influences of spatiotemporal patterns and climate. Ecography 31: 3, 348-358.					Insect outbreaks exert landscape-level influences, yet quantifying the relative contributions of various exogenous and endogenous factors that contribute to their pattern and spread remains elusive. We examine an outbreak of mountain pine beetle covering an 800 thousand ha area on the Chilcotin Plateau of British Columbia, Canada, during the 1970s and early 1980s. We present a model that incorporates the spatial and temporal arrangements of outbreaking insect populations, as well as various climatic factors that influence insect development. Onsets of eruptions of mountain pine beetle demonstrated landscape-level synchrony. On average, the presence of outbreaking populations was highly correlated with outbreaking populations within the nearest 18 km the same year and local populations within 6 km in the previous two years. After incorporating these spatial and temporal dependencies, we found that increasing temperatures contributed to explaining outbreak probabilities during this 15 yr outbreak. During collapse years, landscape-level synchrony declined while local synchrony values remained high, suggesting that in some areas host depletion was contributing to population decline. Model forecasts of outbreak propensity one year in advance at a 12 by 12 km scale provided 80% accuracy over the landscape, and never underestimated the occurrence of locally outbreaking populations. This model provides a flexible approach for linking temperature	
2123	M-IP_FlightMod	Aukema BH, Clayton MK, Raffa KF, 2005. Modeling flight activity and population dynamics of the pine engraver, Ips pini, in the Great Lakes region: effects of weather and predators over short time scales. Popul. Ecol. 47: 1, 61-69.					Ascertaining the relative effects of factors such as weather and predation on population dynamics, and determining the time scales on which they operate, is important to our understanding of basic ecology and pest management. In this study, we sampled the pine engraver Ips pini (Say) (Coleoptera: Scolytidae) and its predominant predators Thanasimus dubius (F.) (Coleoptera: Cleridae) and Platysoma cylindrica (Paykull) (Coleoptera: Histeridae) in red pine plantations in Wisconsin, USA, over 2 years. We sampled both the prey and predators using flight traps baited with the synthetic aggregation pheromone of I. pini. Flight models were constructed using weather variables (temperature and precipitation), counts of bark beetles and their predators, and temporal variables to incorporate possible effects of seasonality. The number of I. pini per weekly collection period was temperature dependent and decreased with the number of predators, specifically T. dubius in 2001 and P. cylindrica in 2002. The number of predators captured each week was also weather dependent. The predators had similar seasonal phenologies, and the number of each predator species was positively correlated with the other. Including a term for the number of prey did not improve the model fits for either predator for either year. Our results suggest that exogenous weather factors strongly affect the flight activity of I. pini, but that its abundance is also affected by direct densitydependent processes acting over weekly time scales. Adult predation during both colonization and dispersal are likely processes yielding these dynamics	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
141	M-WWFD	Ausdley E, Milne A, Paveley N, 2005. A foliar disease model for use in wheat disease management decision support systems. Ann. Appl. Biol. 147, 161-172.					A model of winter wheat foliar disease is described, parameterised and tested for Septoria tritici (leaf blotch), Puccinia striiformis (yellow rust), Erysiphe graminis (powdery mildew) and Puccinia triticina (brown rust). The model estimates disease-induced green area loss, and can be coupled with a wheat canopy model, in order to estimate remaining light-intercepting green tissue and hence the capacity for resource capture. The model differs from those reported by other workers in three respects. First, variables (such as weather, host resistance and inoculum pressure) that affect disease risk are integrated in their effect on disease progress. The agronomic and meteorological data called for are restricted to those commonly available to growers by their own observations and from meteorological service networks. Second, field observations during the growing season can be used both to correct current estimates of disease severity and to modify parameters that determine predicted severity. Third, pathogen growth and symptom expression are modelled to allow the effects of fungicides to be accounted for as protectant activity (reducing infections that occur postapplication) and eradicant activity (reducing growth of presymptomatic infections). The model was tested against data from a wide range of sites and varieties and was shown to predict the expected level of disease sufficiently accurately to support fungicide treatment decisions.	
2081	M-DIABSC_DD	Avila CJ, Milanez JM, Parra JRP, 2002. Prediction of occurrence of Diabrotica speciosa using the laboratory degree-day model. Pesqu. Agropecu. Bras. 37: 4, 427-432.					The goal of this work was to determine the thermal requirements (degree-day) and the prediction of occurrence of adults of Diabrotica speciosa (Coleoptera: Chrysomelidae) under field conditions (screenhouse). The soil and air temperatures were used in a linear model of degree-day, determined for the insect under laboratory conditions. Thermal requirements for the development of D. speciosa were determined by the daily accumulation of thermal units (degree-day), starting from the base development temperature of the insect (11.04ºC), using corn roots cultivated in pots as larvae diet. The value of the thermal constant (K) was used to predict insect occurrence, based on the mean temperatures of the soil and the air recorded during the experimental period. Regardless of the kind of temperature (air or soil) employed for the thermal requirements accounting, the accumulated degreeday values for the development of D. speciosa were significantly lower than the K value achieved in the laboratory. The soil or air temperatures provided a forecast of occurrence of the insect significantly different from that observed experimentally. Nevertheless, the occurrence forecast based in the air temperature was less accurate than when the soil temperatures (registered or estimated) were used.	
1401	M-FA_TempDev	Barfield CS, Mitchell ER, Poe SL, 1978. A temperature-dependent model for fall armyworm development. Ann. Entomol. Soc. Am. 71: 1, 70-74.					The influence of temperature on egg-to-adult developmental times and rates of the fall armyworm, Spodoptera frugiperda (J, E. Smith), was studied in the laboratory at a variety of constant and variable temperatures. Mean total developmental time ranged from 66.6 days (15.6°C) to 18.4 days (35.0°C). Male and female development times were not significantly different. Means and standard deviations of fall armyworm developmental rates (= times^-1) were inputs into a previously derived absolute reaction rate model designed to generate a set of kinetic constants usable in predicting developmental times. The distribution of cohort developmental times was compared to predictions from an existing stochastic cohort model and was found to be in reasonable agreement at all temperatures tested.	The influence of temperature on egg-to-adult developmental times and rates of Spodoptera frugiperda (J.E. Smith) was studied in the laboratory at a variety of constant and variable temperatures. Mean total developmental time ranged from 66.6 days (15.6 deg C) to 18.4 days (35.0 deg C). Male and female development times were not significantly different. Means and standard deviations of S. frugiperda developmental rates (= times-1) were inputs into a previously derived absolute reaction rate model designed to generate a set of kinetic constants usable in predicting developmental times. The distribution of cohort developmental times was compared with predictions from an existing stochastic cohort model and was found to be in reasonable agreement at all temperatures tested
1641	M-BWParasite_dev	Barfield CS, Sharpe PJH, Bottrell DG, 1977. A temperature-driven developmental model for the parasite Bracon mellitor (Hymenoptera: Braconidae). Can. Entomol. 109: 11, 1503-1514.					The influence of temperature on the development of immature stages ofBracon mellitor Say, a braconid parasite of the boll weevil, Anthonomus grandis Boheman, was studied at a series of constant and variable temperatures. Resulting developmental rates and times were compatible with recent advances in the theory of thermal responses exhibited by poikilotherms. Mean development times recorded were in close agreement with predictions calculated from a previously derived absolute reaction rate development model. Bracon mellitor cohort developmental data were also checked against a prototype stochastic cohort development model. In this comparison, observed and predicted probability distributions agreed for constant and variable day/night temperature regimes but showed some differences under sinusoidal temperature regimes.	The influence of temperature on the development of the immature stages of Bracon mellitor Say, an important parasite of Anthonomus grandis Boh. on cotton in the USA, was studied at a series of constant and variable temperatures. Resulting developmental rates and times were compatible with recent advances in the theory of thermal responses exhibited by poikilotherms. Mean development times were in close agreement with predictions calculated from a previously derived absolute reaction rate developmental model. Cohort development data for B. mellitor were also checked against a prototype stochastic cohort development model. In this comparison, observed and predicted probability distributions agreed for constant and variable day and night temperature regimens but showed some differences under sinusoidal temperature regimens.

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2401	SOYGRO	Batchelor WD, McClendon RW, Jones JW, Adams DB, 1989. An expert simulation system for soybean insect pest management. Trans. ASAE (Am. Soc. Agric. Eng.) 32: 1, 335-342.					Aprototype expert system was developed as a decision aid in soybean insect pest management. This expert system, SMARTSOY, incorporated the damage rates of the four primary insects in Georgia: velvetbean caterpillar, soybean looper, corn earworm and southern green stinkbug. Foliage and seed damage rates for these insects were obtained from the state soybean entomologist and incorporated in rule form in a knowledge base using the expert system shell Insight 2+. The SOYGRO crop growth model was included as an extended data base in order to simulate the effects of insect damage. A user interface was developed to allow for the initialization of the SOYGRO model for each field being managed. The user interface also allows scouting report information to be entered in terms of observed crop status and insect populations. SMARTSOY then runs SOYGRO with and without subsequent damage to determine the cost effectiveness of an insecticide application. If an insecticide application is recommended, the rate and type of insecticide is provided to the user. In typical crop and insect scenarios, SMARTSOY has performed well in agreeing with recommendations of the state soybean entomologist. Upon further validation, SMARTSOY could be used by individual growers to make better insect pest management	
2421	SMARTSOY	Batchelor WD, McClendon RW, Jones JW, Adams DB, 1989. An expert simulation system for soybean insect pest management. Trans. ASAE (Am. Soc. Agric. Eng.) 32: 1, 335-342.					A prototype expert system was developed as a decision aid in soybean insect pest management. This expert system, SMARTSOY, incorporated the damage rates of the four primary insects in Georgia: velvetbean caterpillar, soybean looper, corn earworm and southern green stinkbug. Foliage and seed damage rates for these insects were obtained from the state soybean entomologist and incorporated in rule form in a knowledge base using the expert system shell Insight 2+. The SOYGRO crop growth model was included as an extended data base in order to simulate the effects of insect damage. A user interface was developed to allow for the initialization of the SOYGRO model for each field being managed. The user interface also allows scouting report information to be entered in terms of observed crop status and insect populations. SMARTSOY then runs SOYGRO with and without subsequent damage to determine the cost effectiveness of an insecticide application. If an insecticide application is recommended, the rate and type of insecticide is provided to the user. In typical crop and insect scenarios, SMARTSOY has performed well in agreeing with recommendations of the state soybean entomologist. Upon further validation, SMARTSOY could be used by individual growers to make better insect pest management decisions.	
1281	EPURE	Benizri E and Projetti F, 1992. Mise au point d'un modèle de simulation de la rouille brune du blé. Agronomie 12, 97-104					Puccinia recondita f sp tritici is the most important disease of wheat in the south-west of France. The authors propose a model of simulation which is an indicator model of risk. It makes it possible to simulate the evolution of the wheat leaf rust (figs 1, 2). It uses climatic data to simulate various phases of the evolution of the disease; temperature and free moisture (fig 3) seem to be the main limiting factors in the infectious process for our regions. It also quantifies the stages of evelopment of the fungus (figs 4, 5). This method has been tested for several years. A good correlation between the simulations of disease by the model and the field observations has been shown (fig 6). It can therefore be useful for fungicide trials as well as for diffusion of agricultural forecasts.	
2942	M-MPB_PhenSim	Bentz BJ, Logan JA, Amman GD, 1991. Temperature-dependent development of the mountain pine beetle (Coleoptera: Scolytidae) and simulation of its phenology. Can. Entomol. 123: 5, 1083-1094.					Temperature-dependent development of the egg, larval, and pupal life-stages of the mountain pine beetle (Dendroctonus ponderosae Hopkins) was described using data from constant-temperature laboratory experiments. A phenology model describing the effect of temperature on the temporal distribution of the life-stages was developed using these data. Phloem temperatures recorded in a beetle-infested lodgepole pine (Pinus contorta Douglas) were used as input to run the model. Results from model simulations suggest that inherent temperature thresholds in each life-stage help to synchronize population dynamics with seasonal climatic changes. This basic phenological information and the developed model will facilitate both research and management endeavors aimed at reducing losses in lodgepole pine stands caused by mountain pine beetle infestations.	
1661	M-DFTM_delay	Berryman AA, 1978. Population cycles of the Douglas-fir tussock moth (Lepidoptera: Lymantriidae): the time-delay hypothesis. Can. Entomol. 110: 5, 513-518.					A simple population model is used to test the hypothesis that Douglas-fir tussock moth population cycles are caused by time-delays in the responses of density-dependent (negative feedback) processes. The limited data that are available do not seriously conflict with this hypothesis.	A simple population model was used to test the hypothesis that population cycles in Orgyia pseudotsugata (McDunn.) were caused by time delays in the responses of density-dependent (negative feedback) processes. The limited data available, including those given by R.R. Mason for Arizona [see RAE/A 63, 3905], did not seriously conflict with this hypothesis. The model predicted that a new epidemic cycle was starting there in 1976 and that it would peak in 1978. Some properties of the model are discussed in relation to the known biology of O. pseudotsugata.

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
1461	EPIVIT	Bertschinger L, Keller ER, Gessler C, 1995. Characterization of the virus X temperature interaction in secondarily infected potato plants using EPIVIT. Phytopathology 85, 815-819.	Bertschinger L, 1992. Modelling of potato virus pathosystems by means of quantitative epidemiology: an exemplary case based on virus degeneration studies in Peru. Dissertation for doctor of natural sciences, Swiss Federal Institute of Technology (ETH) in Zurich, n°9756.	Bertschinger L, Keller ER, Gessler C, 1995. Development of EPIVIT, a simulation model for contact - and aphid-transmitted potato viruses. Phytopathology 85, 801-814.	Bertschinger L, Scheidegger UC, Luther K, Pinillos O, Hidalgo A, 1990. La incidencia de virus en cultivares nativos y mejorados en la Sierra Peruana. Rev. Latinoam. Papa 3, 62-79.		The model EPIVIT, designed for contact- and aphid-transmitted viruses of tuber crops, simulates the percentage of infected tubers harvested from a potato field. It includes a module for tuber infection of plants with a tuberborne (secondary) infection (efficiency of autoinfection). This module postulates a monomolecular function for the relation between the efficiency of autoinfection and developmental heat, providing a theoretical basis for understanding how an infectious, systematic virus and the environment, represented by temperature, are interacting. The module was calibrated with temperature and antuoinfection data obtained with the modern potato cultivar Yungay (Solanum tuberosum ssp. tuberosum X S. tuberosum ssp. andigena) in five contrasting environments in Perù. Model estimates for potato X potexvirus (PVX), Andean potato mottle comovirus (APMV), potato Y potyvirus (PVY), or potato leafroll luteovirus (PLRV) were obtained. They were more accurate when temperature-sensitive growth rates were used for heat accumulation than with constant accumulation rates. The bell-shaped relationships obtained between heat accumulation rates and apparent temperature differed for each virus, with optimum heat accumulation rates at 28°C for PVY, and between 18 and 28°C, 20 and 25°C, and 23 and 28°C for PLRV, PVX, and APMV, respectively. With PLRV and PVY data. high precision levels ($P<0.05$) were only obtained when the parameter trigger development heat was included. This parameter represents a threshold amount of developmental heat accumulated any time temperature fluctuates into the range between developmental cardinal temperatures, before heat becomes effective for the efficiency of autoinfection. This calibration supports EPIVIT's assumptions regarding the influence of temperature on virus behavior in the host plant. With complete verification of this model component, validation is still needed for final confirmation of the model, as well as an elucidation of the biologi	
941	M-YS-SNB-YL	Bhathal JS, Loughman R, Speijers J, 2003. Yield reduction in wheat in relation to leaf disease from yellow (tan) spot and septoria nodorum blotch. Eur. J. Plant Pathol. 109, 435–443.					Yellow or tan spot (caused by Pyrenophora tritici-repentis) and septoria nodorum blotch (caused by Phaeosphaeria nodorum) occur together and are a constraint to wheat yields in Australia. Recently, higher crop yields and lower fungicide costs have made fungicides an attractive management tool against these diseases.Yield-loss under different rates of progress of yellow spot and septoria nodorum blotch was examined in four experiments over three years to define the relationship between disease severity and yield. In these experiments, differences in disease were first promoted by inoculations either with P. tritici-repentis-infected stubble or aqueous spore suspensions of P. nodorum. Disease progress was further manipulated with foliar application of fungicide. The pattern of disease development varied in each year under the influence of different rainfall patterns. The inoculation and fungicide treatments produced differences in disease levels after flag leaf emergence. The infection of yellow spot or septoria nodorum blotch caused similar losses in grain yield, ranging from 18% to 31%. The infection by either disease on the flag or penultimate leaf provided a good indication of yield-loss. Disease severity on flag leaves during the milk stage of the crop or an integration of disease as area under the disease progress curve on the flag	
2461	M-MPB-PIUCN	Biesinger Z, Powell J, Bentz B, Logan J, 2000. Direct and indirect parametrization of a localized model for the mountain pine beetle - lodgepole pine system. Ecol. Model. 129: 2/3, 273-296.					The dynamic interaction between mountain pine beetles (MPB) and one of its hosts is reviewed briefly. The 'local' projection of a partial differential equation model describing this interaction is employed in model parameter estimation. Methods and assumptions for estimating non-fitted parameter values are given. Assigning values to non-fitted parameters, direct and indirect parametrization techniques are employed to estimate remaining parameter values. The indirect method is quickly and easily applied to many data sets but requires some assumptions and model simplifications. The direct method requires fewer assumptions but is computationally intensive. The results of these two techniques are compared and evaluated.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2442	M-MHT-DENCPO	Bolstad PV, Bentz BJ, Logan JA, 1997. Modelling micro-habitat temperature for Dendroctonus ponderosae (Coleoptera: Scolytidae). Ecol. Model. 94: 2/3, 287-297.					We evaluate two landscape-scale microhabitat temperature prediction models suitable for the mountain pine beetle, Dendroctonus ponderosae Hopkins (coleoptera: scolytidae). Both models are based on maximum and minimum air temperatures measured at meteorological stations. The first, 'lapse' model employs temperature observations for a single nearby weather station, adjusting maximum and minimum temperatures based on elevation differences and appropriate historical vertical lapse rates. The second, 'geographic trend surface' model is based on the locations, elevations, and daily temperature measurements of surrounding weather stations. Predicted air temperatures are adjusted with a radiance-based exposure index to estimate sub-cortical phloem temperatures. Model parameters were estimated using original field measurements at three sites, and using 25 years of regional temperature measurements for sites in the western United States. Stand air temperature and phloem predictions were validated in comparisons with four withheld weather stations, and against one year of independently measured temperatures from four forest stands. Mean errors (observed minus predicted) of daily maximum stand air temperature ranged from -3.9 to 1.5°C, while mean prediction errors for daily minimum air temperatures ranged from -6.3 to 1.7°C. The geographic trend surface model performed slightly better across a range of sites, both for maximum and minimum air temperatures. Phloem temperature predictions were generally more variable, particularly for maximum temperatures on south sides of trees. Standard deviations in prediction errors were generally lower for minimum temperatures and did not differ by model form or tree exposures. © 1997 Elsevier Science B.V. All rights reserved	
2521	M-SBW_StrawbF	Bostanian NJ, Binns M, Kovach J, Racette G, Mailloux G, 1999. Predictive model for strawberry bud weevil (Coleoptera: Curculionidae) adults in strawberry fields. Environ. Entomol. 28: 3, 398-406.					Three different sampling methods (sweep net, D-Vac, tapping into a carton container) were evaluated for Anthonomus signatus Say in strawberry fields. The results suggest that sampling with a sweep net reflects population numbers best. Apredictive model for adult abundance was developed to describe and predict population build-up. The strawberry fields used in the study were in their 2nd yr of production. Overwintering adults generally begin to appear in a strawberry field =300 cumulatitive degree-days (DD) calculated from 1 April at temperatures above O°c. These weevils attain maximum abundance anywhere from 500 to 670 DD. Within that interval, a treatment with cypermethrin or chlorpyriphos was effective against this pest. The summer generation attained maximum abundance anywhere from 1,250 to 1,650 DD. A treatment with chlorpyriphos at 1,679DD reduced the summer generation ofweevils and decreased clipped buds in the field the following year	
3061	M-SN-ET	Brodensen CM, 1997. Economic damage thresholds and the importance of improved information. Agrarwirtschaft. 46: 2, 90-100.					In this paper a model for determining economic thresholds for Septoria nodorum in winter wheat is derived. Because the population dynamics of this disease are mainly influenced by uncertain weather factors and plant protection management is characterized by recursive relationships, a stochastic dynamic programming framework is chosen. One main outcome of the calculations is that the threshold values do not increase continuously over time, as often stated, but rather should stay high in early and middle periods. Simulation runs in which the value of different information sources are estimated confirm this. These show that, when dealing with assumptions about the potential for damage of the pathogen and the effectiveness of the plant protection product, inspection for infestation and weather forecasting appear highly profitable.	
2481	HELSYS	Brown LG, McClendon RW, Jones JW, 1979. Computer simulation of the interaction between the cotton crop and insect pests. Trans. ASAE (Am. Soc. Agric. Eng.) 22: 4, 771-774.					Acotton crop model, a boll weevil model, and a Heliothis spp. model have been interfaced to facilitate the investigation of various pest management strategies. The effects of insecticide applications on the boll weevil and Heliothis spp. populations are included.	The combination of models predicting cotton crop status, boll weevil and Heliothis spp. population dynamics was undertaken to enable the investigation of insect pest management options, as well as various hypotheses concerning the protection of the crop yield with min. producer costs. The effect of insecticide spray applications on combined insect models and the resulting effect on crop yield is given for 2 insecticide application schedules. Results are given for 1 set of weather data under conditions of limited and no irrigation, 1 initial Heliothis spp. population, 1 boll weevil over-wintering rate, and 2 insecticide application schedules
2482	BWEEV	Brown LG, McClendon RW, Jones JW, 1979. Computer simulation of the interaction between the cotton crop and insect pests. Trans. ASAE (Am. Soc. Agric. Eng.) 22: 4, 771-774.					Acotton crop model, a boll weevil model, and a Heliothis spp. model have been interfaced to facilitate the investigation of various pest management strategies. The effects of insecticide applications on the boll weevil and Heliothis spp. populations are included.	The combination of models predicting cotton crop status, boll weevil and Heliothis spp. population dynamics was undertaken to enable the investigation of insect pest management options, as well as various hypotheses concerning the protection of the crop yield with min. producer costs. The effect of insecticide spray applications on combined insect models and the resulting effect on crop yield is given for 2 insecticide application schedules. Results are given for 1 set of weather data under conditions of limited and no irrigation, 1 initial Heliothis spp. population, 1 boll weevil over-wintering rate, and 2 insecticide application schedules

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
1161	M-WLR-S	Burleigh JR, Eversmeyer MG, Roelfs AP, 1972. Development of Linear Equations for Predicting Wheat Leaf Rust. Phytopathology 62, 947-953.					A stepwise multiple linear regression computer program was used to identify six biological and meteorological variables to predict wheat leaf fUSt severilies 14, 21, and 30 days afler the date of prediction (DP). Significant variables were leaf fUStseverity on DP, growth stage of wheat on the date predicted, average hours of free moisture during 7 days prior to DP, number of days of precipitation >= 0.25 mm during 7 days prior to DP, a fungal growth function, and fungal infection function. Linear equations that combined those variables had R2 values from 0.722 to 0.527. Equations predicted leaf rust severity within +/- 1, 3, and 12%, 14, 21, and 30 days in advance, respectively. Equations with leaf rust severity as an inoculum variable were more accurate than those without an inoculum variable and those with spore numbers as the inoculum variable.	
1821	WATBUG	Butler GDJr and Scott DR, 1976. Two models for development of the corn earworm on sweet corn in Idaho. Environ. Entomol. 5: 1, 68-72.					Oviposition of the com earworm, Heliothis zea (Boddie), on corn in Idaho was observed to decrease from July 1-15 and then to increase again. A simple model based on heat units above 55°P predicted when the mid-July oviposition would begin. A thermodynamic model (WATBUG) was used to simulate seasonal development of the population, produce life tables, and evaluate the effect of control treatments.	Oviposition of Heliothis zea (Boddie) on maize in Idaho was observed to decrease from 1-15 July and then to increase again. A simple model based on heat units above 55 deg F predicted when the mid-July oviposition would begin. A thermodynamic model (WATBUG) was used to simulate seasonal development of the population, produce life tables and evaluate the effect of control treatments.
1841	M-CEHUTModel	Butler GDJr and Scott DR, 1976. Two models for development of the corn earworm on sweet corn in Idaho. Environ. Entomol. 5: 1, 68-72.					Oviposition of the com earworm, Heliothis zea (Boddie), on corn in Idaho was observed to decrease from July 1-15 and then to increase again. A simple model based on heat units above 55°P predicted when the mid-July oviposition would begin. A thermodynamic model (WATBUG) was used to simulate seasonal development of the population, produce life tables, and evaluate the effect of control treatments.	Oviposition of Heliothis zea (Boddie) on maize in Idaho was observed to decrease from 1-15 July and then to increase again. A simple model based on heat units above 55 deg F predicted when the mid-July oviposition would begin. A thermodynamic model (WATBUG) was used to simulate seasonal development of the population, produce life tables and evaluate the effect of control treatments.
2841	M-Mid-TermFM	Cao KQ, Zhu ZY, Wang SM, 1995. The establishment of a mid-term forecast model for wheat leaf rust. Acta Phytophylacica Sinisa 22: 1, 57-61.					Based on the investigation data on wheat leaf rust from both Baoding and Xinji City during the recent ten years, a mid-term forecast model for wheat leaf rust was established. It is: Y = -20.59 + 9.12X1 + 0.85X2 +1.41X3 In which, X1 means the index of cultivar's rust resistance, X2 and X3 represent the total precipitation and the total precipitation times in the first 20 days of April, respectively, and Y is the disease index of leaf rust at the mid-term of grain filling. By validation on historical data, the accuracy rate of forecast was as high as 80%. The model is applicable to the forecast of the severity of leaf rust in the central and southern parts of Hebei Province.	
1901	M-CLBDeath_LowTemp	Casagrande RA and Haynes DL, 1976. A predictive model for cereal leaf beetle mortality from sub-freezing temperatures. Environ. Entomol. 5: 4, 761-769					A predictive model is developed relating mortality of adult cereal leaf beetles (Oulema melanopus, L.) to the duration and severity of continuous cold exposures. Experiments reveal the importance of a seasonal change in cold tolerance, preconditioning, and recovery from successive cold exposures in determining mortality from exposures of the type encountered in the field.	A predictive model is developed relating mortality of adults of Oulema melanopus (L.) to the duration and severity of continuous cold exposures. Experiments revealed the importance of a seasonal change in cold tolerance, preconditioning and recovery from successive cold exposures in determining mortality from exposures of the type encountered in the field.
1601	M-HOMLTR_Phen	Castle SJ, Naranjo SE, Bi JL, Byrne FJ,Toscano NC, 2005. Phenology and demography of Homalodisca coagulata (Hemiptera: Cicadellidae) in southern California citrus and implications for management. Bull. Entomol. Res. 95: 6, 621-634.					Populations of Homalodisca coagulata (Say) were sampled from citrus orchards in southern California, USA to characterize and quantify seasonal occurrences of nymphs and adults with the goal of identifying management opportunities through well-timed treatments and/or natural enemy releases. Higher densities of H. coagulata in 2001 contributed to a complete seasonal profile that began in early spring with the emergence of first instar nymphs and their progression through five nymphal instars lasting until mid-August. Adult emergence began in mid-June with peak adult densities attained from mid to late August followed by a gradual decline through autumn. A persistent and significant male bias was observed in the adult sex ratio from the time of first emergence through mid-October in oranges; the same trend was present in lemons, but with more variability. Adult densities gradually declined through the winter months into the following spring before rapidly increasing again in June as the 2002 spring generation of nymphs began emerging as adults. The seasonal timing of nymphs and adults in 2002 was nearly identical to that observed the previous year. Phenology data from both years were incorporated into a stochastic, temperature dependent model that predicts the occurrences of H. coagulata stages through time. Applications of imidacloprid early in the spring generation of nymphs proved very effective at reducing nymphs and sustaining lower densities of adults through summer.	Populations of <i>Homalodisca coagulata</i> (Say) were sampled from citrus orchards in southern California, USA to characterize and quantify seasonal occurrences of nymphs and adults with the goal of identifying management opportunities through well-timed treatments and/or natural enemy releases. Higher densities of <i>H. coagulata</i> in 2001 contributed to a complete seasonal profile that began in early spring with the emergence of first instar nymphs and their progression through five nymphal instars lasting until mid-August. Adult emergence began in mid-June with peak adult densities attained from mid to late August followed by a gradual decline through autumn. A persistent and significant male bias was observed in the adult sex ratio from the time of first emergence through mid-October in oranges; the same trend was present in lemons, but with more variability. Adult densities gradually declined through the winter months into the following spring before rapidly increasing again in June as the 2002 spring generation of nymphs began emerging as adults. The seasonal timing of nymphs and adults in 2002 was nearly identical to that observed the previous year. Phenology data from both years were incorporated into a stochastic, temperature-dependent model that predicts the occurrences of <i>H. coagulata</i> stages through time. Applications of imidacloprid early in the spring generation of nymphs proved very effective at reducing nymphs and sustaining lower densities of adults through summer

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
221	M-WLB-S	Coakley SM, McDaniel LR, Shaner G, 1985. Model for predicting severity of Septoria tritici blotch on winter wheat. Phytopathology 75, 1245-1251.					A statistical model was developed to predict severity of septoria tritici blotch (pathogen teleomorph: Mycosphaerella graminicola) on susceptible Monon winter wheat at the Purdue Agronomy Farm. Disease severity at adjusted Julian day 170 (which on the average was 17 June, 26 days after the average heading date of 22 May) was significantly correlated ($P<0.05$) with nine meteorological variables for the period between 2 March and 13 May. An equation was developed for predicting percent disease severity (y) at adjusted Julian date 170 based on 1973-1984 data. The equation is $y = 147.480 - 3.025 X1 - 2.093 X2$ ($R2 = 0.86$), in which X1 is the total consecutive days (8- 19 days) without precipitation between 26 March and 4 May, and X2 is the total consecutive days (12- 24 days) between 4 April and 3 May that minimum temperature was equal to or less than 7 C. Model selection and validation were based on the use of different regression analysis techniques, including Mallow's Cp statistic, Allen's PRESS statistic, and the variance inflation factor.	
2422	M-SUR-WASTE	Crohn DM, Faber B, Downer AJ, Daugovish O, 2008. Probabilities for survival of glassy-winged sharpshooter and olive fruit fly pests in urban yard waste piles. Bioresour. Technol. 99: 5, 1425-1432.					Glassy-winged sharpshooter (Homolodisca coagulate) and olive fruit fly (Bactrocera oleae) were introduced into unturned, chipped yard waste piles to evaluate their survival with time and depth within the piles. In all three trials, no pests lasted more than 14 d, and in no trial did pests survive more than 4 d at the 30 and 100 cm depths. No survivors were found after 14 d in any of the treatments at any depth. Neither of the pests survived 100 cm after 2 d. A mathematical model for describing pest survival probabilities is described. The model modifies time according to the Arrhenius equation in order to include heat effects on pest survival and can be used to determine exposure times necessary to eliminate these pests with a determined statistical probability. Model projections suggest that for conditions similar to this study, there is 99% confidence that all glassy-winged sharpshooter eggs would be eliminated from 1000 infected leaves in 6.1 d at 15 cm depth and in 4.8 d at 30 cm or below. Olive fruit fly larvae at these depths would require 4.8 and 4.1 d, respectively, for 1000 infected olive fruits. Projected elimination times at the surface were longer, 6.5 d for sharpshooter eggs and 14.3 d for fruit fly larvae.	
2322	M-BW_Disp	Culin J, Brown S, Rogers J, Scarborough D, Swift A, Cotterill B, Kovach J, 1990. A simulation model examining boll weevil dispersal: historical and current situations. Environ. Entomol. 19: 2, 195-208.					A linear deterministic simulation model was developed to examine the historical rate of movement of the boll weevil, Anthonomus grandis grandis Boheman, across the southeastern United States. This manuscript addresses the hypotheses proposed during the initial invasion of the boll weevil that cotton production and prevailing winds were the primary factors regulating movement of this pest. A modification of the historical model was used to predict defensive strategies required to maintain boll weevil-free areas resulting from the current program efforts.	
2242	M-BW_Mort	Curry GL, Cate JR, Sharpe PJH, 1982. Cotton bud drying: contributions to boll weevil mortality. Environ. Entomol. 11: 2, 344-350.					A model of immature boll weevil, Anthonomus grandis Hoheman, mortality as it relates to cotton, Gossypium hirsutum L., bud drying is presented. The model synthesizes the effects of bud size, temperature, and relative humidity on immature survival. Favorable comparisons with two experimental data sets demonstrate that the bud drying mortality model contains the essential components and mechanisms to adequately explain this major (in many regions) contributing factor to immature weevil mortality.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2961	M-RUST-FR	de Vallavieille-Pope C, Huber L, Leconte M, Goyeau H, 1995. Comparative effect of temperature and interrupted wet periods on germination, penetration, and infection of Puccinia recondita f. sp. tritici and P. striiformis on wheat seedlings. Phytopathology 85, 409-415.					Under optimal temperature and nonlimiting wetness duration, the infection efficiency (defined as the proportion of inoculated urediniospores causing lesions on wheat seedling leaves) was 12 times greater for Puccinia recondita f. sp. tritici than for P. striiformis. Penetration of both species, however, was similarly affected by a 1-h dry period interrupting a 24-h wet period 1, 2, 4, 6, 8, or 16 h after inoculation at several temperatures between 5 and 30 C. Appressoria from germinated P. r. tritici urediniospores prior to penetration were unable to survive the I-h dry period. An interruption of the wet period by a dry period did not affect ungerminated urediniospores, which were able to infect leaves during a subsequent dew period. The minimal continuous dew period necessary for infectionincreased from 4 to 6 h at optimal temperatures (8 C for P. striiformis, 15 C for P. r. tritici) to at least 16 h at suboptimal temperatures. Infection by P. r. tritici occurred over a wide range of temperatures (5-25 C), whereas infection by P. striiformis was restricted to a narrower range (5-12 C). Percentage of infection as a function of the duration of the continuous dew period was described by a Richards's function with temperature-dependent parameters. For a dry period interrupting the 24-h dew period before the minimal continuous dew period necessary for infection, percentage of infection at specific temperatures was fitted by a negative exponential function of time of interruption. If the dry period occurred after the minimal dew duration for infection, percentage of infection was the same as with a continuous wet period.	
2981	M-RUST-FR-V2	de Villavieille-Pope C, Huber L, Leconte M, Bethenod O, 2002. Preinoculation effects of light quantity on infection efficiency of Puccinia striiformis and P. triticina on wheat seedlings. Phytopathology 92, 1308-1314.					In a previous study under controlled conditions, a model was developed to predict the infection efficiency for the wheat leaf and stripe rust fungi based on temperature and dew period during the 24 h after inoculation. The two pathogens differed in their maximum infection efficiency under controlled conditions for temperature and dew period, the infection efficiency was 12 times greater for Puccinia triticina than for P. striiformis. In the present study, the model was validated by field results to predict P. triticina infection efficiency as a function of temperature and dew period only. However, this model failed to predict infection efficiency caused by P. striiformis in the field. The model was adapted to include the effects of light quantity on infection efficiency. Wheat seedlings, grown in climate-controlled rooms and exposed to various regimes of light duration and intensity for 24 h in either field or controlled conditions, were inoculated and incubated in climate-controlled rooms under optimal dew and temperature conditions. Quantity of natural or artificial light (light intensity × duration) received by the plants prior to inoculation enhanced infection efficiency of wheat seedlings inoculated by P. striiformis. Infection efficiency increased from 0.4 to 36% depending on the	
461	M-WFHB-Risk	De Wolf ED, Madden LV, Lipps PE, 2003. Risk assessment models for wheat Fusarium head blight epidemics based on within-season weather data. Phytopathology 93, 428-435.	De Wolf E, Lipps P, Miller D, Knight P, Molineros J, Francl L, Madden L, 2004. Evaluation of prediction models for wheat Fusarium head blight in the U.S. 2004, p. 439 In: Proc. 2nd Intl. Symposium Fusarium Head Blight, 11-15 Dec. 2004. Orlando, FL.	Hollingsworth CR, Mewes JJ, Motteberg CD, Thompson WG, 2006. Predictive accuracy of a Fusarium head blight epidemic risk forecasting system deployed in Minnesota. Plant Health Progress October, 1-6.			Logistic regression models for wheat Fusarium head blight were developed using information collected at 50 location-years, including four states, representing three different U.S. wheat-production regions. Non-parametric correlation analysis and stepwise logistic regression analysis identified combinations of temperature, relative humidity, and rainfall or durations of specified weather conditions, for 7 days prior to anthesis, and 10 days beginning at crop anthesis, as potential predictor variables. Prediction accuracy of developed logistic regression models ranged from 62 to 85%. Models suitable for application as a disease warning system were identified based on model prediction accuracy, sensitivity, specificity, and availability of weather variables at crop anthesis. Four of the identified models correctly classified 84% of the 50 location-years. A fifth model that used only pre-anthesis weather conditions correctly classified 70% of the location-years. The most useful predictor variables were the duration (h) of precipitation 7 days prior to anthesis, duration (h) that temperature was between 15 and 30 degrees C 7 days prior to anthesis, and the duration (h) that temperature was between 15 and 30 degrees C and relative humidity was greater than or equal to 90%. When model performance was evaluated with an independent validation set (n=9), prediction accuracy was only 6% lower than the accuracy for the original data sets. These results indicate that narrow time periods around crop anthesis can be used to predict Fusarium head blight epidemics.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
161	GIBSIM	Del Ponte EM, Fernandes JMC, Pavan W, 2005. A risk infection simulation model for Fusarium head blight in wheat. Fitopatol. Bras. 30, 634–642.	Del Ponte EM, Fernandes JMC, Pavan W, Pierobom CR, 2004. Simulação da dinâmica do florescimento do trigo como base para um modelo de simulação de giberela (Simulating flowering dynamics in wheat as a basis for a Fusarium head blight risk model). Revista Brasileira de Agrociência 10, 323-331.	Fernandes JMC and Pavan W, 2002. A phenology-based predictive model for Fusarium Head Blight of Wheat. Anais, 2002 National Fusarium Head Blight Forum, Erlanger, KY, USA, 2002, 154-158.			Fusarium Head Blight (FHB) is a disease of great concern in wheat (Triticum aestivum). Due to its relatively narrow susceptible phase and environmental dependence, the pathosystem is suitable for modeling. In the present work, a mechanistic model for estimating an infection index of FHB was developed. The model is process-based driven by rates, rules and coefficients for estimating the dynamics of flowering, airborne inoculum density and infection frequency. The latter is a function of temperature during an infection event (IE), which is defined based on a combination of daily records of precipitation and mean relative humidity. The daily infection index is the product of the daily proportion of susceptible tissue available, infection frequency and spore cloud density. The model was evaluated with an independent dataset of epidemics recorded in experimental plots (five years and three planting dates) at Passo Fundo, Brazil. Four models that use different factors were tested, and results showed all were able to explain variation for disease incidence and severity. A model that uses a correction factor for extending host susceptibility and daily spore cloud density to account for post-flowering infections was the most accurate explaining 93% of the variation in disease severity and 69% of disease incidence according to regression analysis.	
1341	M-RDGZ	Del Ponte EM, Fernandes JMC, Pierbom CR, 2005. Factors affecting density of airborne Gibberella zeae inoculum. Fitopatol. Bras. 30, 55-60.					Fusarium head blight (FHB) is a disease of increasing concern in the production of wheat (Triticum aestivum). This work studied some of the factors affecting the density of airborne Gibberella zeae inoculum. Spore samplers were placed at the edge of a field in order to observe spore deposition over a period of 45 days and nights in September and October, the period that coincides with wheat flowering. Gibberella zeae colonies were counted for each period and values transformed to relative density. A stepwise regression procedure was used to identify weather variables helpful in predicting spore cloud density. In general, a predominant night-time spore deposition was observed. Precipitation and daily mean relative humidity over 90% were the factors most hightly associated with peak events of spores in the air. Models for predicting spore cloud density simulated reasonably well with the fluctuation of airborne propagules during both night and day, with potential to be integrated into an FHB risk model framework.	
1041	M-AM-WFHB	Detrixhe P, Chandelier A, Cavelier M, Buffet D, Oger R, 2003. Development of an agrometeorological model integrating leaf wetness duration estimation to assess the risk of head blight infection in wheat. Aspects of Applied Biology 68, 199- 204.					In order to assess the risk of head blight infection in winter wheat in Belgium, an agrometeorological model based on an interpolation of meteorological data (temperature, relative humidity, wind speed and incoming short-wave and longwave radiation) collected from meteorological stations network and on weather radar data has been developed to simulate the leaf wetness duration on a grid size of 1 km x 1 km. The first results of the model under development are presented in this article.	
164	M-WKB-S	Diwan-Singh, Raj-Singh, Rao VUM, Karwasra SS, Beniwal MS, 1996. Relation between weather parameters and Karnal bunt (Neovossia indica) in wheat (Triticum aestivum). Indian J. Agric. Sci. 66: 9, 522-525.					An experiment was conducted to study the relationship between weather parameters and Karnal bunt (N. indica [Tilletia indica]) of wheat. The relationship obtained between the meteorological parameters and the average infection of karnal bunt in wheat was weak for standard meteorological weeks 7 and 8. However, the occurrence of rains during standard meteorological week 9 resulted in a substantial change of R2 (coefficient of determination) values of meteorological parameters like max. temp. (0.5-0.6) and RH at evening (0.6-0.7). It is concluded that multiple regression models have better applicability and by using 3 or 4 meteorological parameters Karnal bunt infection can be predicted with reasonable reliability. The multiple regression model using different weather parameters for standard week 12 was found to be the best.	
1081	M-SM-SN	Djurle A and Yuen JE, 1991. A simulation model for Septoria nodorum in winter wheat. Agric. Sys. 37: 2, 193-218.					A disease model that simulates a Septoria nodorum epidemic was coupled to a wheat growth model. The structure of the composite model includes delays for latency and infectious periods and procedures for simulation of lesion growth and vertical spore distribution. Standard weather data were used to drive the model. Results from a sensitivity analysis showed the weather conditions to be the most important factors in the development of an epidemic in a particular year. Spore dispersal parameters and threshold criteria for dispersal and infection were also important. The amount of initial inoculum was less important.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
921	M-GB-RDI	Djurle A, Ekbom B, Yuen JE, 1996. The relationship of leaf wetness duration and disease progress of glume blotch, caused by Stagonospora nodorum, in winter wheat to standard weather data. Eur. J. Plant Pathol. 102: 1, 9-20.					Leaf wetness duration explained up to 42% of the rate of disease increase (RDI) for S. nodorum [Leptosphaeria nodorum] in winter wheat. Leaf wetness duration was accumulated over a 5-day period and correlated with rate of disease increase after a 7-day lag period. Standard weather variables explained 20-34% of the disease increase. The relevance of these statistical models to disease prediction is discussed.	
2402	M-SM-WBC	Drapek RJ, Fisher G, Croft BA, 1997. Spatial modelling of the influence of corn planting and wind blocking features on catch of Helicoverpa zea (Boddie) in pheromone traps and subsequent pest damage. Agric. Sys. 54: 3, 381-397.					A spatial model of capture of Helicoverpa zea (Boddie) males in pheromone traps was developed as a UNIX scriptJile running geographical information system commands (GRASS, v. 4.0). This model was developed to explain how spatialpatterns of corn planting and wind-blockingfeatures act to modify pheromone-trap-based earworm damage predictions on sweet corn. In the model, we sought to create a modtjied cumulative moth catch value that correlated more strongly with subsequent pest damage than unmodtjied cumulative trap catch values. The model looks at daily changes in wind direction and pheromone plume movement, calculates contribution to catch levels for all locations around the trap, and mod$es the catch so that it only includes moths within the planting area of interest. We describe this model in detail and show field data resultsfrom 2 years.	
241	M-PR-Surv1	Eversmeyer MG and Kramer CL, 1996. Modeling winter and early spring survival of Puccinia recondita in wheat nurseries during 1890 to 1993. Plant Dis. 80, 490-493.					Survival of Puccinia recondita inoculum between wheat crops is critical to the occurrence of severe leaf rust epidemics, which result in economic yield reductions in the Great Plains wheat-producing region of the U.S. Meteorological variables occurring prior to spring green-up of the wheat crop during 1980 to 1993 at Manhattan, KS, were used to model survival of inoculum throughout the winter and early spring in wheat nurseries. Stepwise multiple regression techniques were used to determine those weather variables that explained the most variation in levels of inoculum surviving on 15 March. Inoculum levels were recorded on a 0 to 9 scale with 0 indicating no inoculum survival and 9 indicating inoculum on all plants. Daily maximum and minimum temperatures, fungal temperature equivalence function, precipitation and snow cover, cumulative precipitation and fungal temperature function, and daily deviations from the 10-year average of those variables were averaged for 10-day periods prior to a date of prediction and used as independent variables. Models that explained 99% of the variation in overwintering with five or six variables were developed for the fifteenth of each month from December through March. Models for December, January, and February used five of the same variables, but the minimum temperature deviation used in the December model was replaced by the January rainfall deviation in the January and February models. The model for March used a different set of temperature variables and included daily deviations in snow cover for December and February to explain a significant portion of the overwintering of P. recondita inoculum.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
242	M-PR-Surv2	Eversmeyer MG and Kramer CL, 1998. Models of Early Spring Survival of Wheat Leaf Rust in the Central Great Plains. Plant Dis. 82, 987-991.					Severe leaf rust epidemics, which result in economic yield reductions in the Great Plains wheatproducing region of the United States, are usually initiated by Puccinia recondita f. sp. tritici inoculum that has survived in the local field from the previous wheat crop until early spring. Models were developed for an epidemic year beginning at physiological maturity of one wheat crop to maturity of the following wheat crop. Meteorological variables for periods prior to final tiller development of the wheat crop during 1980 to 1992 at several sites in the central Great Plains winter-wheat-production area were used to model inoculum survival from one wheat crop until early spring of the next crop. Stepwise multiple regression was used to identify weather variables that explained the most variation in inoculum survival at the final tiller development wheat growth stage. Inoculum survival was recorded on a 0 to 9 scale with 0 indicating no survival and 9 indicating inoculum on all wheat plants in the field. Independent variables used in development of models were daily deviations from the 10-year average of maximum and minimum temperature, fungal temperature equivalence function, cumulative fungal temperature function, precipitation, cumulative precipitation, and snow cover averaged for 10-day periods prior to dates inoculum forecasts were desired. Models were constructed to forecast inoculum survival from data collected prior to fall wheat planting, the beginning of winter dormancy of the wheat, and the final tiller development wheat growth stage. Of the observed occurrences of leaf rust overwintering, 70% were forecast by models constructed using weather data prior to wheat planting decision time. Overwintering could be forecast by models constructed with data prior to the wheat entering winter dormancy 80% of the time. Models constructed with data collected prior to final tiller development in the spring forecast overwintering of leaf rust inoculum 95% of the time. R	
1201	M-BYDV-risk	Fabre F,Pierre JS, Dedryve CA, Plantegenest M, 2006. Barley yellow dwarf disease risk assessment based on Bayesian modelling of aphid population dynamics. Ecol. Model. 193, 457-466.	Fabre F, Dedryver CA, Leterrier JL, Plantegenest M, 2003. Aphid abundance on cereals in autumn predicts yield losses caused by Barley yellow dwarf virus. Phytopathology 93, 1217-1222.				A stochastic population dynamics model is proposed to improve integrated pest management strategies against the aphid Rhopalosiphum padi, the main Barley yellow dwarf virus (BYDV) vector in winter cereals during autumn in Europe. The model is based on a temperature-dependent simulation of R. padi population dynamics. The model requires a single early assessment of the proportion of plants infested by aphids. To account for sampling errors and for uncertainty caused by the numerous factors acting on aphid population dynamics under field conditions, Bayesian statistical inference was used. The model allows assessment of the probability distribution of the area under the curve of the percentage of plants infested by R. padi during autumn, a predictor of the need for insecticide sprays against BYDV vectors. The accuracy of model predictions was tested on an independent data set collected from 1995 to 1998 in the main French small grain production areas. The use of this model as a basis for a user-friendly decision support system improving BYDV management is discussed.	
1561	M-TWD-AALS	Filajdic N and Sutton TB,1992. Influence of temperature and wetness duration on infection of apple leaves and virulence of different isolates of Alternaria mali. Phytopathology 82: 11, 1279-1283.						from CAB: The effect of combinations of 9 different temp. (4-36 degrees C) and 8 wetness periods (2-48 h) on the infection of Delicious apple seedlings by A. mali was studied. Disease severity increased with increased wetness duration over all the temp. tested and was greatest from 12 to 28 degrees . The influence of temp. and wetness duration on infection of apple seedlings by A. mali was described by the model: Yij=-6.4580 + 0.1853Ti + 0.0912Wj - 0.0033Tsuperscript 2i - 0.0030Wsuperscript 2j + 0.0194TiWj - 0.0005Tsuperscript 2iWj, in which Y=log10 (percentage of leaf area covered with lesions + 0.01), T = temp. (C), W = wetness duration (h), i = individual temp. treatment and j = individual wetness duration treatment. The predicted opt. temp. for infection was 23.5 degrees . At this temp., 5.1 h of wetness was required for light infection (0.2% leaf area covered with lesions). The model derived from lab. data was tested in the field with healthy seedlings surrounded by inoculated ones. Conidia of A. mali were trapped during 14 wetness periods; infection criteria were met during 10 of these periods. No false negatives occurred; however, 6 false positives were recorded. A predictive model for first occurrence of Alternaria blotch developed in South Korea was evaluated under North Carolina conditions; it predicted first

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2582	MEHLTAU	Friedrich S and Boyle C, 1998. Simulation of infection probability of powdery mildew in winter wheat. Mathematical and control applications in agriculture and horticulture. Proceedings of the 3rd IFAC workshop, Hannover, Germany, 28 September-2 October 1997, 243-248.					A mathematical model is reported that can simulate sporulation, spore dispersal, infection probability and incubation of powdery mildew of winter wheat (caused by Erysiphe graminis f.sp. tritici). Using hourly meteorological input variables (temperature and air humidity within the canopy, wind speed and precipitation) different phases of the pathogens infection cycle was simulated. The deterministic model calculates the diurnal course of spore dispersal within the naturally infected canopy. Precipitation, high wind velocities and both very low and very high vapour pressure deficits acted negatively on computed infection probability. Measured and calculated incubation periods correlated well, with 82% of the calculated incubation periods differing less than 24h from the observed values. It is suggested that using this model it is possible to detect periods of high infectivity and the model provides reliable help in decision making with fungicide application.	
2581	M-SPB_PopDynTX	Friendenberg NA, Sarkar S, Kouchoukos N, Billings RF, Ayres MP, 2008. Temperature Extremes, Density Dependence, and Southern Pine Beetle (Coleoptera: Curculionidae) Population Dynamics in East Texas. Environ. Entomol. 37: 3, 650-659.					Previous studies of the southern pine beetle, Dendroctonus frontalis Zimm., established that its population in east Texas responds to a delayed density-dependent process, whereas no clear role of climate has been determined.Wetested two biological hypotheses for the inßuence of extreme temperatures on annual southern pine beetle population growth in the context of four alternative hypotheses for density-dependent population regulation. The signiÞcance of climate variables and their interaction with population regulation depended on the model of density dependence. The best model included both direct and delayed density dependence of a cubic rather than linear form. Population growth declined with the number of days exceeding 32 C, temperatures previously reported to reduce brood survival. Density dependence also changed with the number of hot days. Growth was highest in years with average minimum winter temperatures. Severely cold winters may reduce survival, whereas warm winters may reduce the efÞciency of spring infestation formation. Whereas most previous studies have incorporated climate as an additive effect on growth, we found that the form of delayed density dependence changed with the number of days 32 C. The interaction between temperature and regulation, a potentiallycommonphenomenon in ecology, may explainwhy southern pine beetle outbreaks do not occur at perfectly regular intervals. Factors other than climate, such as forest management and direct suppression, may have contributed signiÞcantly to the timing, severity, and eventual cessation of outbreaks since the mid-1950s	
1181	M-SPB-outbreak	Gan J, 2004. Risk and damage of southern pine beetle outbreaks under global climate change. For. Ecol. Manag. 191: 1/3, 61-71.					This study, using the panel data modeling approach, investigates the relationships between climatic variables and southern pine beetle (SPB) (Dendroctonus frontalis Zimmermann) infestations and assesses the impact of global climate change on SPB infestation risk and damage. The panel data model alleviates possible collinearity among climatic variables, accounts for the effect of omitted or unobserved variables, and incorporates natural and human adaptation, thus representing a more robust approach to analyzing climate change impacts. SPB outbreaks in Louisiana and Texas appeared to move together; infestations in Alabama, Arkansas, Georgia, Florida, Mississippi, South Carolina, North Carolina, and Tennessee were highly correlated; and Virginia demonstrated its unique temporal pattern of SPB outbreaks. Salvage harvest was found to be helpful in lessening future infestation risk. Warmer winters and springs would positively contribute to SPB outbreaks with spring temperature showing a more severe and persistent impact than winter temperature; increases in fall temperature would ease SPB outbreaks; and summer temperature would have a mixed impact on SPB infestations. Compared to temperature, precipitation would have a much smaller impact on SPB infestations. While increases in the	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
401	M-WLB-I	Gladders P,Paveley ND, Barrie IA, Hardwick NV, Hims MJ, Langton S, Taylor MC, 2001. Agronomic and meteorological factors affecting the severity of leaf blotch caused by Mycosphaerella graminicola in commercial wheat crops in England. Ann. Appl. Biol. 138, 301-311.					Factors affecting the severity of leaf blotch on the two upper leaves of wheat plants in crops at the milky ripe growth stage (GS 73-75) were investigated using survey data from 3513 randomly selected wheat crops sampled during 1985-1996. Year-to-year variation in disease severity was greater than spatial variability at county level, although both showed significant differences. The presence of disease above a 5% severity threshold was modelled using random effects logistic regression (Generalised Linear Mixed Model), which enabled risk variables measured at the field level to be combined with meteorological variables estimated at county level. The final model included terms for the fixed effects of disease resistance rating, date of sowing, high risk septoria periods in May and June, number of fungicide sprays and number of days with frost (£ -2°C) in November. The percentage of crops above the threshold decreased with later sowing, increased number of November frost days and increased number of fungicide sprays. In contrast, high risk septoria periods (rain splash events) in May and June showed a positive correlation with the percentage of crops above the threshold. There were benefits from using resistant cultivars. The model showed that a range of risk variables were of broadly equivalent importance in determining the development of leaf blotch. These risk variables should be integrated in any scheme designed to support fungicide use decisions.	
2001	M-ACC-WRIV	Gottwald TR and Irey M. 2007. Post-hurricane analysis of citrus canker II: predictive estimation of disease spread and area potentially impacted by various eradication protocols following catastrophic weather events. Plant Health Progress. April, 1-15.	Irey M, Gottwald TR, Graham JH, Riley TD, Carlton G, 2006. Post-hurricane analysis of citrus canker spread and progress towards the development of a predictive model to estimate disease spread due to catastrophic weather events. Plant Health Progress August, 1-12.				The impact of 2005 Hurricane Wilma on the dissemination of Xanthomonas axonopodis pv. citri (Xac), the cause of Asiatic citrus canker (ACC), and subsequent disease development was examined and predictions for the areas into which Xac was likely to have spread from known sources of infection were developed. In addition, the effect of the current 579-m (1900-ft) ACC eradication protocol, resulting in removal of all "exposed trees" with a 579-m radius of a known Xac-infected tree, was calculated via GIS analysis and expressed as the predicted "impacted area." The GIS calculations were based on the extension of the previous published wind-rain index vector (WRIV) model. The model extension consisted of the incorporation of an estimate of distance of spread due to various combinations of wind and rain from data collected during the 2004 hurricane season. An inverse power law dissemination function was used to describe regional dispersal from a point focus of Xac infection. Alternative eradication protocol (distances) to the 579-m protocol were evaluated in association with the GIS analyses and used to examine the effect of eradication distance on predicted "impacted area." The results of these analyses were used by state and federal regulatory agencies and commercial citrus producer groups to evaluate the feasibility of continued ACC eradication.	
2102	M-BW_TempDev	Greenberg SM, Setamou M, Sappington TW, Liu TX, Coleman RJ, Armstrong JS, 2005. Temperature-dependent development and reproduction of the boll weevil (Coleoptera: Curculionidae). Insect Science 12: 6, 449-459.					Effects of temperature on development, survival, and fecundity of boll weevil, Anthonomus grandis grandis Boheman, were assessed at 10, 11, 12, 15, 20, 25, 30, 35, 45, and 46°C; 65% relative humidity; and a photoperiod of 13:11 (L: D) h. The mortality of boll weevil immature stages was 100% at 12°C and decreased to 36.4% as the temperature increased to 25°C. When the temperature increased from 30°C to 45°C, the mortality of weevils also increased from 50.1% to 100%. From 15°C to 35°C, the boll weevil preimaginal development rate was linearly related to temperature. The average development time of total boll weevil immature lifestages decreased 3.6-fold and the preovipositional period decreased 3.3-fold when the temperature was increased from 15°C to 30°C. The lower threshold for development was estimated at 10.9, 6.6, 7.0, and 9.0°C for eggs, larval, pupal, and total immature stages, respectively, with total thermal time requirement to complete immature stages of 281.8 DD (degree day) (15°C) and 247.8 DD (35°C). At 11°C and 46°C, weevil females did not oviposit. Longevity of adult females decreased 4.6-fold with increasing temperatures from15°C to 35°C. Fecundity increased with increasing temperatures up to 30°C and significantly decreased thereafter. These findings will be useful in	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
162	M-LEMAME-PH	Guppy JC and Harcourt DG, 1978. Effects of temperature on development of the immature stages of the cereal leaf beetle, Oulema melanopus (Coleoptera: Chrysomelidae). Can. Entomol. 110, 257-263.					Survival rates and development rates were obtained in the laboratory for Oulema melanopus (L.) at 12 constant temperatures. Rates of survival for eggs were high at 12-32 deg C, but no eggs hatched at 6 or 34 deg C. Larvae survived at 8-32 deg C with no marked rise in mortality at the extremes; mortality at 34 deg C increased with larval age. Pupal survival was low at all temperatures from 8-32 deg C, ranging from 3% at these limits to 40% at 14-30 deg C. The duration of the egg and larval stages decreased with rise in temperature up to 30 deg C, and that for pupae to 32 deg C. Developmental rates plotted against temperature did not deviate significantly from fitted curves of the form 1/y = K/(1 + ea-bx). The threshold for complete development was at some point between 6 and 8 deg C. The thermal requirements above a threshold of 7 deg C for the eggs, 4 larval instars and pupae were calculated as 105, 41, 36, 43, 46 and 282 day-degrees, respectively. The temperature sums for O. melanopus in field plots in Ottawa did not differ significantly from those expected. Similar calculations based on a threshold of 9 deg C predicted development equally well.	
2721	M-CLB_FieldDyn	Gutierrez A.P, Denton WH, Shade R, Maltby H, Burger T, Moorehead G, 1974. The Within-Field Dynamics of the Cereal Leaf Beetle (Oulema melanopus (L.)) in Wheat and Oats. J. Anim. Ecol. 43: 3 (Oct.), 627-640.					(1) A model of the within-field dynamics of the cereal leaf beetle (Oulema melanopa L.)) in wheat and oats describes the phenology and development of beetle populations developing primarily on oats. (2) Submodels for simulating the effects of soil moisture and weather on the development of the host plant are also included. (3) An effort is made to provide a method for assessing the effects of beetle-feeding on yield reductions.	A model based on data collected in Indiana in 1966 and 1972 is given of the within-field dynamics of Oulema melanopus (L.) on wheat and oats; it describes the phenology and development of beetle populations developing primarily in oats. Submodels for simulating the effects of soil moisture and weather on the development of the food-plant are also included. An effort is made to provide a method for assessing the effects on yield of feeding by the Criocerid.
2801	M-SB_univ	Hansen EM, Bentz BJ, Turner DL, 2001. Temperature-based model for predicting univoltine brood proportions in spruce beetle (Coleoptera: Scolytidae). Can. Entomol. 133: 6, 827-841.					The spruce beetle, Dendroctonus rujipennis (Kirby), has possible life cycles of I or 2 years. Empirical and experimental evidence suggest that temperature is the primary regulator of these life-history pathways. These different life cycles potentially result in substantial differences in population dynamics and subsequent spruce mortality. A multiyear field study was conducted in Utah, Colorado, and Alaska, to monitor spruce beetle development under a variety of field conditions with concurrent air temperature measurements. This information was used to model the tree- or standlevel proportion of univoltine beetles as a function of air temperature. Temperatures were summarized as averages, cumulative time, and accumulated heat units above specified thresholds over various seasonal intervals. Sampled proportions of univoltine insects were regressed against the summarized temperature values in logistic models. The best predictive variable, as evaluated by Akaike's Information Criterion, was found to be cumulative hours above a threshold of 17°C elapsed from 40 to 90 days following peak adult funnel-trap captures. Because the model can be used to forecast trends in spruce beetle populations and associated spruce mortality, it is a tool for forest planning.	
1361	M-CT-SWW	Hansen JG, Secherb JM, Jorgensen LN, Welling B, 1994. Thresholds for control of Septoria spp. in winter wheat based on precipitation and growth stage. Plant Pathol. 43, 183-189.					A simple forecasting model for Septoria spp. in winter wheat was developed based on historical data (1980-89) including precipitation, growth stage, disease severity and yield response to fungicide treatments. The number of days with precipitation = 1 mm, calculated during a 30-day period starting at the beginning of stem elongation (GS 32), correlated well with attacks of Septoria spp. later in the season and with the yield response in trials with fungicide treatments. Seven or 8 days with rainfall = 1 mm was suggested as a threshold for Septoria treatment. Model development and possible further improvements are discussed.	
2424	M-BYDV-DESSAC module	Harrington R, Burgess AJ, Taylor MS, Foster GN, Morrison S, Ward L, Tones S, Rogers R, Barker I, Walters KFA and Morgan D, 1998. Spread of BYDV - DESSAC module. Management through understanding: research into practice. Proceedings of the sixth HGCA R&D conference on cereals and oilseeds, Robinson College, Cambridge, UK, 8-9 January 1998, 14.1-14.18.					We are developing a system to support decisions on the need to control the aphid vectors of barley yellow dwarf virus in autumn-sown wheat and barley. A model of secondary spread which is driven by weather data is the core of the system. It is intended that the model will be initiated on the basis of the number of winged aphids caught in suction trap samples. A regional risk assessment will result and this will be made field-specific on the basis of relationships found between field characteristics and virus incidence. The system will be a module of DESSAC (DEcision Support System for Arable Crops). Data for scientific validation of the model have been gathered and will be used to assess its performance. The system will require commercial validation before it becomes generally available. Its use will enable farmers to rationalise insecticidal treatments to control aphid vectors of BYDV.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2423	M-OFF_HeatSurv	Hayes CF and Young H, 1989. Extension of model to predict survival from heat treatment of papaya infested with oriental fruit flies (Diptera: Tephritidae). J. Econ. Entomol. 82: 4, 1157-1160.					The previously published model used for calculating survival of Dacus dorsalis Hendel in papaya (Carica papaya L. var. Solo) subjected to a hot-water immersion treatment is extended. The new model allows the calculation of survival for treatments including the vapor heat and dry air treatments. The physical parameter needed to extend the model to these treatments is h, the surface heat transfer coefficient. Measurements of h are reported for papaya in high- and low-humidity environments of moving and static air.	
1921	M-CLBDeath_age	Helgesen RG and Haynes DL, 1972. Population dynamics of the cereal leaf beetle, Oulema melanopus (Coleoptera: Chrysomelidae): a model for age specific mortality. Can. Entomol., 104: 6, 797-814.					The cereal leaf beetle, Oulcma melanopus (L.), has rapidly increased its numbers and range since it was discovered in Michigan in 1962. We have shown in this report that intraspecific density-dependent mortality is the major constraint on survivorship. We have attempted to quantify survival within a generation from the egg stage to the adult. Larval mortality varies among populations. Density-dependent mortality, caused by intraspecific competition, accounts for most of the variation of withingeneration survival of the cereal leaf beetle in wheat and oats. Mortality in the first instar on oats and the fourth instar on wheat and oats is a linear function of the logarithm of total egg density. Establishment of the first instar on oats appears to become more difficult as density increases because leaf surface disturbance and interference with larger larva increases. Competition for food accounts for the increase in mortality of the fourth instar in both wheat and oats as density increases. Egg survival, survival of the first instar on wheat and in the second, third, and pupal stage in both crops are constants with respect to density. These constants can be expected to change with respect to other environmental parameters however, e.g. host variety, planting date, rainfall, etc.	Ouleme melanopus (L.) attacks cereal crops in Michigan and has increased in numbers and range since it was discovered there in 1962 [cf. RAE/A 51, p. 505]. In the work on the effect of density and food-plant on its population dynamics here described, larval mortality was shown to vary among populations, and density-dependent mortality, caused by intraspecific competition, accounted for most of the variation in within-generation survival on wheat and oats. Mortality in the first larval instar on oats and the fourth instar on oats and wheat was shown to be a linear function of the logarithm of total egg density. The establishment of the first-instar larvae on oats appeared to become more difficult as density increased, because disturbance by other larvae on the leaf and interference by larger larvae increased. Competition for food accounted for the increase in mortality in the fourth instar on both wheat and oats as density increased. Egg survival, survival in the first larval instar on wheat and in the second and third instars and the pupal stage on both crops were constants with respect to density. These constants can be expected to change with respect to other environmental parameters, such as food-plant, planting date and rainfall, however
861	DONcast	Hooker DC, Schaafsma AW, Tamburic-Ilincic L, 2002. Using weather variables preand post-heading to predict deoxynivalenol content in winter wheat. Plant Dis. 86, 611-619.	Hooker DC and Schaafsma AW, 2003. The DONcast model: using weather variables pre- and post-heading to predict deoxynivalenol content in winter wheat. Aspects of Applied Biology 68, 117-122.				Substantial economic losses have occurred because of unacceptable concentrations of deoxynivalenol (DON) in wheat. Accurate predictions of DON in mature grain at wheat heading are needed to make decisions on whether a control strategy is needed. Our objective was to identify important weather variables, and their timing, for predicting concentrations of DON in mature grain at wheat heading. We measured the concentration of DON in 399 farm fields in southern Ontario, Canada, from 1996 to 2000. DON varied in field samples from undetectable to over 29 µg g-1. Weather variables, such as daily rainfall, daily minimum and maximum air temperatures, and hourly relative humidity, were estimated for each field from nearby weather stations and were normalized to the date of 50% head emergence. Stepwise multiple regression procedures determined the most important weather variables and their timing around heading. DON was responsive to weather in three critical periods around heading. In the first period, 4 to 7 days before heading, DON generally increased with the number of days with >5 mm of rain and decreased with the number of days of <10°C. In the second period, 3 to 6 days after heading, DON increased with the number of days of rain >3 mm and decreased with days exceeding 32°C. In the third period, 7 to 10 days after heading, DON increased with number of days with >3 mm of rain. A relationship between relative humidity and DON was not detected. Overall, 73% of the variation in the concentration of DON was explained by using weather from all three critical periods. Concentrations of DON <2.0 µg g-1 were predicted best; in fact, concentrations of DON of <1.0 µg g-1 were predicted correctly on over 89% of the fields used to train the model.	
501	PESTSIM_OUL	Hunkàr Zemankovics M, 1991. Simulation model of Oulema melanopus in the winter-wheat ecosystem. EPPO Bulletin 21: 3, 539-548.	Rossenberg D, Holz F, Freber B, Wenzel V, 1986. PESTSIM-OUL a model for simulation of Oulema spp. population. Computer aided modelling and simulation of winter wheat agroecosystem (AGROSIM-W) for integrated Pest management (ed. Elbert W) - Tagungsbericht no 242. Academie der Landwirtschaftwissenschaften der DDR (Berlin).				Simulation system sonches (Simulation of Nonlinear Complex Hierarchical Ecological Systems) is a tool for computer-aided experimental investigation of the dynamic behaviour of ecological systems. A winter-wheat agroecosystem was modelled with the help of sonches. The whole model consists of several submodels. One of them is the growth-development model of winter wheat itself. The others are pest models. The model of cereal leaf beetle (Oulema melanopus) was investigated. The main driving force in the model is daily mean temperature. The temperature inside the plant canopy is different from the temperature outside it (at the meteorological station). A microclimate model was used to modify the measured temperature values. Simulation experiments were carried out to show the effect of using microclimate data instead of standard meteorological data. The difference between the temperature inside and outside the canopy depends on radiation. The days of the vegetation period were classified by sunshine duration: clear, cloudy and overcast days. Winter wheat treated with different amounts of nitrogen fertilizer has a different canopy structure. The microclimate inside the canopy alters according to density. Results of simulation experiments in the form of population dynamics are presented	A winter wheat ecosystem was modelled using SONCHES (simulation of nonlinear complex hierarchical ecological systems). The model consists of several submodels, including a growth-development model of winter wheat and pest models. The model for the chrysomelid <i>Oulema melanopus </i>was investigated. The main driving force in the model was daily mean temperature. The temperature inside the plant canopy differed from that outside. A microclimate model was used to modify the measured temperature values. Simulation experiments were carried out to show the effect of using microclimate data instead of standard meteorological data. The difference between the temperature inside and outside the canopy depended on radiation. Winter wheat treated with different amounts of nitrogen fertilizer had a different canopy structure. The microclimate inside the canopy altered according to plant density.

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2542	M-MPB-DISP	Jackson PL and Murphy B, 2004. Modelling of mountain pine beetle transport and dispersion using atmospheric models. Information Report - Pacific Forestry Centre, Canadian Forest Service BC-X-399, 133-145.					The mountain pine beetle population in the British Columbia central interior has reached epidemic proportions. Mountain pine beetles move actively through flight over a few kilometers within a stand, and passively through advection by the wind, within and above a forest canopy. Passive dispersal is likely responsible for between-stand and landscape-scale spread of the population. A strategy for the testing and use of atmospheric numerical models to predict the passive movement of mountain pine beetles is described. Preliminary synoptic climatology results indicate that typical weather patterns associated with weather conducive to mountain pine beetle flight are similar to average summertime conditions, except the surface high pressure ridge influencing the weather over BC is stronger than normal. An atmospheric simulation of a situation conducive to mountain pine beetle emergence and flight showed that the above canopy winds and temperatures had considerable spatial and temporal variability, indicating that treating the atmosphere simplistically as a "constant" in mountain pine beetle population models may not lead to satisfactory results.	
1263	MIDAS	Jensen AL and Jensen FV, 1996. MIDAS - An Influence Diagram for Management of Mildew in Winter Wheat. In: Proceedings of the Twelfth Conference for Uncertainty in Artificial Intelligence, 349-356.	Jensen AL, 1995. A probabilistic model based decision support system for mildew management in winter wheat. PhD thesis, Aalborg University, Dina Research Report 39.				We present a prototype of a decision support system for management of the fungal disease mildew in winter. The prototype is based on an influence diagram which is used to determine the optimal time and dose of mildew treatments. This involves multiple decision opportunities over time, stochasticity, inaccurate information and incomplete knowledge. The paper describes the practical and theoretical problems encountered during the construction of the influence diagram, and also the experience with the prototype.	
2061	HTI	Jhorar OP, Mavi HS, Sharma I, Mahi GS, Mathauda SS, Singh G. 1992. A biometeorological model for forecasting Karnal bunt disease of wheat. Plant Dis. Research 7: 2, 204-209.	Baker RHA, Sansford CE, Gioli B, Miglietta F, Porter JR, Ewert F, 2005. Combining a disease model with a crop phenology model to assess and map pest risk: Karnal bunt disease (Tilletia indica) of wheat in Europe. Plant protection and plant health in Europe: introduction and spread of invasive species, held at Humboldt University, Berlin, Germany, 9-11 June 2005, 89-94.	Stansbury CD and McKirdy SJ, 2002. Forecasting climate suitability for Karnal bunt of wheat: a comparison of two meteorological methods. Australas. Plant Pathol. 31: 1, 81-92.	Mavi HS, Jhorar OP, Sharma I, Gurmeet Singh, Mahi GS, Mathauda SS, Aujla SS, 1992. Forecasting Karnal bunt disease of wheat - a meteorological method. Cereal Res. Commun. 20:1-2, 67-74.			From CAB: The evening RH and max. temp. from 9th to 11th standard meteorological weeks (SMWs), number of rainy days from 9th to 11th SMWs and sunshine duration for 9th SMW were highly correlated with this disease, caused by Neovossia [Tilletia] indica. Max. temp. (r=-0.88) and sunshine duration (r=-0.73) were negatively related, while evening RH (r=0.93) and number of rainy days (r=0.71) were positively related to the disease. Regression analysis showed that evening RH and max. temp. can be put in a disease model as independent variables in simple regression equations. A humid thermal index (HTI) had the highest correlation with disease (r=0.94) and was used for developing a forecasting model.
1541	M-RHAGIN_Phen	Jones VP, Alston DG, Brunner JF, Davis DW, Shelton MD, 1991. Phenology of the Western Cherry Fruit Fly (Diptera: Tephritidae) in Utah and Washington. Ann. Entomol. Soc. Am. 84: 5, 488-492.					The flight period of the western cherry fruit fly, Rhagoletis indifferens Curran, was investigated in Utah tart cherry, Prunus cerasus L., orchards from 1983 to 1989 and in Washington sweet cherry, Prunus avium L., orchards between 1982 and 1988. In Utah, flies were first detected on 31 May 1989, but the average time of first detection was 9 June across nine site-years. In Washington, the first fly was detected on 23 May 1988, with an average first detection time of 1 June in the three site-years. On a degree-day (DD) scale (lower threshold of 5°C and no upper threshold), detection of the first fly averaged 573 ± 19.0 DD (x ± SEM) in Utah and 592 ± 42.1 DD in Washington. A degree-day model using the combined data for Utah and Washington consistently predicted emergence for all but one Utah site without synchronization of the model based on capture of the first fly	The flight period of <i>Rhagoletis indifferens </i>was investigated in Utah on tart cherry, <i>Prunus cerasus, </i>during 1983-89 and in Washington on sweet cherry, <i>P. avium, </i>during 1982-88, using standard Pherocon AM traps. In Utah, adults were first detected between 31 May and 18 June, with an average first trapping date of 9 June. In Washington, the first adult was detected between 24 May and 8 June, with an average first detection time of 1 June. On a day-degree scale (lower threshold of 5 degrees C and no upper threshold), detection of the first adult averaged 573 +or- 19.0 day-degrees C in Utah and 592 +or- 42.1 day-degrees C in Washington. A day-degree model, using the combined data for Utah and Washington, consistently predicted emergence for all but one Utah site without synchronization of the model based on capture of the first adult

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2583	M-SPB_ClStress	Kalkstein LS, 1976. Effects of climatic stress upon outbreaks of the southern pine beetle. Environ. Entomol. 5: 4, 653-658.					The frequency and severity of outbreaks of the southern pine beetle, Dendroctonus frontalis Zimmerman, appear to be controlled by climatic variations. Monthly tabulations of southern pine beetle activity in eastern Texas were correlated with various climatic variables derived from the Thornthwaite water balance to determine climate-beetle relationships and to develop a predictive technique capable of evaluating future insect activity based upon past climatic conditions. The magnitude of potential evapotranspiration 3 mo prior to the evaluated insect activity represented the most important climatic component within the regression model. In general, the intensity of insect activity was directly related to moisture surplus and deficit, and inversely related to summer potential evapotranspiration. The regression model was tested against the most recent southern pine beetle outbreak data to determine its predictive capabilities. The model predicted the severe outbreak which occurred July 1973, and isolated the climatic trigger mechanisms responsible for the outbreak.	
1061	M-BYDV-SM	Kendall DA, Brain P, Chinn NE, 1992. A simulation model of the epidemiology of barley yellow dwarf virus in winter sown cereals and its application to forecasting. J. Appl. Ecol. 29: 2, 414-426.						A computer model is described which simulates the spread of barley yellow dwarf luteovirus (BYDV) by aphids in winter cereals in SW England. The model has as a theoretical base the dynamic interaction between 2 temp. dependent rate processes: (i) the frequency of virus transmission to uninfected plants by infected aphids, and (ii) the frequency of virus acquisition by uninfected aphids from infected plants. A distinction is made between virus spread into crops by alate migrant vectors (primary transmission), and more localized spread within crops mainly by apterous vectors (secondary transmission). Both types of spread may occur concurrently. Probabilities of multiple infection, and effects of this on the rate processes in the model, are described by a generalized frequency distribution. Vector dispersal and the latent periods, following transmission and acquisition of virus, are represented as constant functions of thermal time. Simulations used field data of plant and aphid populations sampled every few weeks in crops of winter barley and wheat at Long Ashton near Bristol during 1978-89. The infectivity of autumn migrant aphids caught each year in a suction trap was measured by feeding transmission tests. Daily max-min screen temp. used to estimate thermal time were obtained from records
961	M-Rust-US-MS	Khan MA and Trevathan LE, 1997. Relationship of air, soil temperatures and rainfall to leaf rust development at three locations in Mississippi. Pakistan Journal of Phytopathology. 9: 1, 41-49.						From CAB: Environmental data from 3 locations (Holly Springs, Poplarville and Starkville) in Mississippi, USA, during 1986-90 were used to develop a disease predictive model for leaf rust infection on winter wheat (cvs. Coker 916 and 983, Florida 301 and 302, and Rosen); data from Starkville, Mississippi, during 1986-90 were used for validation. Natural inoculum of Puccinia recondita f.sp. tritici was relied upon for infection. Monthly and weekly air and soil temperatures and total rainfall were regressed against disease severity recorded at Feekes' growth stages 10.5 and 11.1. All data were subjected to analysis of variance and multiple regression analysis. Disease severity was significantly different for wheat varieties over the 5-year period. Leaf rust severity was greater at Holly Springs than at Starkville or Poplarville. Overall, a model based on weekly maximum soil temperature, minimum air temperatures and total rainfall from March to May at Holly Springs fit the data well (Rsuperscript 2=0.72). The regression equation of leaf rust development, based on weekly maximum soil temperature, minimum air temperature and total rainfall from Holly Springs during 1986-90, was significantly different from that of Starkville during 1986-90. Observed and predicted leaf rust severity values at Holly springs were in agreement for most varieties but differed by years.
1241	M-MRMs-LR-S	Khan MA, 1997. Evaluation of multiple regression models based on epidemiological factors to predict leaf rust on wheat. Pakistan Journal of Agricultural Sciences 34: 1/4, 1-7.					Experimental plots of Lu-26, Pak-81 and Fsd-85 were established during 1995-96 and 1996-97 wheat growing seasons. The crop was artificially inoculated with leaf rust urediniospores and natural inoculum was also relied upon for infection. Stepwise regression was used to develop multiple regression models by employing weekly maximum and minimum air temperatures, rainfali, relative humidity, wind speed and 24 hr wind movement as independent variables while leaf rust severity served as dependent variable. R2, Mallows C, and mean square error were used to select the best model. Environmental conditions and leaf rust severity recorded on wheat varieties differed in two seasons. During 1995-96, two multiple regression models containing weekly maximum and minimum temperatures and maximum temperature and relative humidity explained more than 93% of the variability in leaf rust development on Fsd-85 and Pak-81 respectively. During 1996-97, weekly minimum temperature and relative humidity explained more than 90% of the variability in disease development on three varieties. Observed leaf rust severity values and those predicted by these models conformed to each other for most of the varieties.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
1481	M-AALS	Kim CH, Cho WD, Kim SC.1986. An empirical model for forecasting Alternaria leaf spot in apple. Korean Journal of Plant Protection 25: 4, 221-228.	Filajdic N and Sutton TB. 1992. Influence of temperature and wetness duration on infection of apple leaves and virulence of different isolates of Alternaria mali. Phytopathology 82: 11, 1279-1283.					From CAB: This model to predict initial occurrence and subsequent progress of A. mali was based on modified degree day temp. and frequency of rainfall during 3 yr of field experiments. Climatic factors were analysed on 10-d bases, from 20 Apr. to the end of Aug., and were used as variables for the model construction. Cumulative degree portion (CDP) > 10 degrees C in the daily av. temp. was used as a parameter to determine the relationship between temp. and initial disease occurrence. This value was considered as the temp. threshold. After reaching 160 CDP time of initial occurrence was determined by frequency of rainfall. At least 4 periods of rainfall were necessary to be accumulated for initial occurrence of the disease after passing the temp. threshold. Disease progress after initial incidence usually followed the pattern of frequency of rainfall accumulated in those periods. Apparent infection rate (r) in the general differential equation dx/dt = xr(1-x) for individual epidemics when x is the disease proportion and t is time, was a linear function of accumulation rate of rainfall frequency (Rc) and could be estimated directly from the equation r = 1.06Rc-0.11 (Rsuperscript 2 = 0.993). Disease severity (x) after t time could be predicted using an exponential equation derived from the differential equation. There was a
881	M-DON-NNM	Klem K, Vanova M, Hajslova J, Lancova K, Sehnalova M, 2007. A neural network model for prediction of deoxynivalenol content in wheat grain based on weather data and preceding crop. Plant, Soil and Environment 53: 10, 421-429.					Deoxynivalenol (DON) is the most prevalent Fusarium toxin in Czech wheat samples and therefore forecasting this mycotoxin is a potentially useful tool to prevent it from entering into food chain. The data about DON content in wheat grain, weather conditions during the growing season and cultivation practices from two field experiments conducted in 2002–2005 were used for the development of neural network model designed for DON content prediction. The winning neural network is based on five input variables: a categorial variable – preceding crop, and continuous variables – average April temperature, sum of April precipitation, average temperature 5 days prior to anthesis, sum of precipitation 5 days prior to anthesis. The most important input parameters are the preceding crop and sum of precipitation 5 days prior to anthesis. The weather conditions in April, which are important for inoculum formation on crop debris are also of important contribution to the model. The weather conditions during May and 5 days after anthesis play only an insignificant role for the DON content in grain. The effect of soil cultivation was found inferior for model function as well. The correlation between observed and predicted data using the neural network model reached the coefficient R2 = 0.87.	
2702	M-AMF_DDEmerg	Laing JE and Heraty JM, 1984. The use of degree-days to predict emergence of the apple maggot, Rhagoletis pomonella (Diptera: Tephritidae), in Ontario. Can. Entomol. 116: 8, 1123-1129.					Adult flies of the apple maggot, Rhagoletis pomonella (Walsh), were monitored for 6 years at Guelph, Ontario using aerial and ground-emergence traps. Two degree-day (°D) models to predict adult emergence were tested. Fifty percent of the adults were captured in an average of 809 ± 50 (SD) °D8.7 and first capture was at 638 ± 60°D6.4. Degree-day models which have been proposed previously and those developed in this study were only slightly more accurate than average calendar date for predicting adult emergence. Differences in °D requirements for emergence in each year were correlated with the length of cold period and the correlation suggested that the length of cold period preceding morphogenesis affects either the number of °D required to complete postdiapause development or the threshold temperature for development.	
2343	M-PC_Dev	Lan Z, Scherm H, Horton DL, 2004. Temperature-dependent development and prediction of emergence of the summer generation of plum curculio (Coleoptera: Curculionidae) in the southeastern United States. Environ. Entomol. 33: 2, 174-181.					Timely insecticide application against the summer generation (first field generation) of the plum curculio, ConotracheluB nenuphar Herbst, is critical in the production of peach and other stone fruits in the southeastern United States. In the absence of monitoring tools that are effective during midseason when the adults of this generation emerge, a temperature-based emergence model would be useful as an alternative decision aid. In this study, we determined rates oflarval development (from oviposition to peak emergence of larvae) and pupal development (from larval emergence to peak emergence of adults) for two populations of C. nenuphar in constant temperatures ranging from = 11-37°C, developed linear regression models to describe the relationships between developmental rate and temperature for both stages, and estimated degree-day requirements for completing development from these models. The lower threshold temperature was 11.1 and 8.7°C for larval and pupal development, respectively. The thermal time requirement from oviposition to peak emergence of larvae was 215.5 DD, and peak emergence of adults occurred 442.4 DD later. For model validation, rearing experiments were carried out with both populations in fluctuating temperatures in the greenhouse and outdoors. Observed degree-day requirements were not	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2441	M-SM-CATOGRAND	Legaspi BCJr, Carruthers RI, Morales-Ramos JA, 1996. Functional response as a component of dynamic simulation models in biological control: the Catolaccus-boll weevil system. Ecol. Model. 89: 1/3, 43-57.					A simulation model using Time Varying Distributed Delays was created on the HERMES (Hierarchical Environment for Research Modelling of Ecological Systems) of the USDA/ARS with the purpose of evaluating different forms of functional response components in dynamic simulations of biological control systems. The specific host-parasitoid life system used in the evaluation was the boll weevil-Catolaccus grandis system. Four forms of functional response equations were tested: Type I, Type II, a Type II modified to yield constant attack probabilities under constant host:parasitoid ratios, and a temperature-dependent Type II. Simulation runs showed that the parasitoid is potentially capable of considerable suppression of the host population. Predicted host numbers under Type I and II equations did not differ markedly, because realistic host numbers per parasitoid were often found in the linear portion of the Type II equation. The probability of attack using a Type I equation was always near 100% despite arbitrarily increasing the host population to create a wide range of host:parasitoid ratios. The Type II equation resulted in fluctuating attack probabilities which steadily declined as host : parasitoid ratio exceeded 100 : 1. The modified Type II equation yielded attack probabilities starting at 52% and steadily declining to about 8% when host:parasitoid ratios neared 1000:1. We introduced a realistic, but hypothetical, relationship between functional response and temperature. Simulations using actual weather data from the Rio Grande Valley of Texas suggest that there is little difference between using Types I or II equations, but that the effect of temperature on attack rates is substantial in this system. Caution should be used when incorporating data from experiments into simulation models because experimental conditions are often unrealistically optimal. We discuss the possible importance of temperature and other diurnal or environmental events on funct	
3041	M-WS-FMs	Liang ZZ and Huang J, 1991. A study on stage prediction models for wheat scab disease. Acta Phytophylacica Sinica 13: 2, 117-122.					This study analyzed the complex relations between wheat scab disease and environmental factors such as climate and activity of the fungus. Using discriminant analysis under Fisher rule, Fuzzy comprehensive judgement and Exs comprehensive decision-marking method, three stage forecast models were built, namely, early stage, middle stage and late stage of rough to precise and precise to rough which could not only counteract disadvantages in the middle and long forecasts, but also prevent passive situations due to arrangement of prevention and control based on short forecast. Each stage forecast accorded with the historic situations up to 86.96-100%. Through application during 1986-1988, they could forecast correctly.	
1121	M-DIAACI	Liu YingHong and Tsai JH, 2000. Effects of temperature on biology and life table parameters of the Asian citrus psyllid, Diaphorina citri Kuwayama (Homoptera: Psyllidae). Ann. Appl. Biol. 137: 3, 201-206.					The development, survivorship, longevity, reproduction, and life table parameters of the Asian citrus psyllid, Diaphorina citri Kuwayama were evaluated at 10°C, 15°C, 20°C, 25°C, 28°C, 30°C and 33°C. The populations reared at 10°C and 33°C failed to develop. Between 15°C and 30°C, mean developmental period from egg to adult varied from 49.3 days at 15°C to 14.1 days at 28°C. The low-temperature developmental thresholds for 1st through 5th instars were estimated at 11.7°C, 10.7°C, 10.1°C, 10.5°C and 10.9°C, respectively. A modified Logan model was used to describe the relationship between developmental rate and temperature. The survival of the 3rd through 5th nymphal instars at 15-28°C was essentially the same. The mean longevity of females increased with decreasing temperature within 15-30°C. The maximal longevity of individual females was recorded 117, 60, 56, 52 and 51 days at 15°C, 20°C, 25°C, 28°C and 30°C, respectively. The average number of eggs produced per female significantly increased with increasing temperature and reached a maximum of 748.3 eggs at 28°C (P 0.001). The population reared at 28°C had the highest intrinsic rate of increased (0.199) and net reproductive rate (292.2); and the shortest population doubling time (3.5 days) and mean generation time (28.6 days)	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2682	M-MPB_EggDev	Logan JA and Amman GD, 1986. A distribution model for egg development in mountain pine beetle. Can. Entomol. 118: 4, 361-372.					Mountain pine beetle (Dendroctonus ponderosae Hopkins) population dynamics, as well as potential for outbreaks and resulting tree mortality, are related in part to habitat temperature. As a first step in development of a life-stage, event-oriented simulation model, we have modeled the temperature-dependent development of the egg stage. The completed model includes a full description of variation in developmental rates and is capable of predicting duration and eclosion patterns for any temperature regime. This model was parameterized using data obtained from constant-temperature experiments at temperatures of 8, 10, 12.5, 15, 20, 25, and 30°C. Validation experiments were conducted for constant temperatures of 15, 17.5,22.5, and 27.5°C and for variabletemperature regimes of 15 ± 5 and 15 ± 10°C. Validation results indicated that the model is capable of accurately describing the emergence curve for constant temperatures below 27.5°C. The model also faithfully represents emergence under variable temperatures of 15 ± 10°C. Potential reasons for lack of model fidelity in describing emergence at constant high temperatures and for 15 ± 5°C are discussed in the text	
2321	M-MPB_Season	Logan Ja and Bentz BJ, 1999. Model analysis of mountain pine beetle (Coleoptera: Scolytidae) seasonality. Environ. Entomol. 28: 6, 924-934.					The mountain pine beetle, Dendroctonus ponderosae Hopkins, is a natural disturbance agent of considerable consequence in western pine forests. This economically and ecologically important insect has a strong requisite for maintaining a strict seasonality. Given this ecological requirement, it is somewhat surprising that no evidence for diapause or other physiological timing mechanism has been found. Seasonality and phenological timing for this species are apparently under direct temperature control. We investigate the consequences of direct temperature control by Þrst constructing a computationally efÞcient phenology model based on previously published temperature dependent developmental data. We explored the dynamic properties of this model when subjected to observed microhabitat temperatures representing a range of thermal habitats from one region of the mountain pine beetle distribution. We also investigated the consequences of global climate change on phenology and seasonality. Our results indicate that an adaptive seasonality is a natural consequence of the interaction between developmental parameters and seasonal temperatures. Although this adaptive phenology appears to be resilient to temperature ßuctuations, changes in climate within the magnitude of predicted climate change under a CO2 doubling scenario are capable of shifting a thermally hostile environment to a thermally benign environment. Similarly, increasing temperature by the same amount resulted in phenological disruption of a previously favorable thermal habitat. We discuss the implications of these results for restricting the current distribution of mountain pine beetle, and the potential for shifting distribution caused by global climate change.	
2243	M-HELIZE_Emerg	Logan JA, Stinner RE, Rabb RL, Bacheler JS, 1979. A descriptive model for predicting spring emergence of Heliothis zea populations in North Carolina. Environ. Entomol. 8: 1, 141-146.					A conceptual model is formulated which des.cribes over~in~er develo\?mental rate for Heliothis zea (Boddie) pupae. An analytic function for predlction of spnng emergence as a function of temperature is developed through the techmque of matched asymptottc expansions. The resultant model is fit to observed pQst-diapause developmental rat~s measured at various constant temperature regimes. From these data, parameters were estimated for 10, 50, and 90 percentile emergence. A field spring emergenc~ model tS presented which Includes the temporal variation in post-diapa~se morphogenet.lc developme~t, ~he ~patlal dl~tribution of overwintering pupae in the SOli, and the spatial/temporal dlstnbutlOn of soil temperature. Model results are compared to an observed field emergence	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
1321	M-SEPTMP	Lovell D J, Hunter T, Powers S J, Parker S R, Van den Bosch F, 2004. Effect of temperature on latent period of septoria leaf blotch on winter wheat under outdoor conditions. Plant Pathol. 53, 170-181.					Batches of two winter wheat cultivars (Riband and Apollo) were inoculated with conidia of Mycosphaerella graminicola at weekly intervals over a 2 year period. Following 72 h incubation, plants were placed in ambient temperatures ranging between -7 and 32°C with mean batch temperatures of 2·9–20·2°C. Latent period until the first visible symptoms ranged between 11 and 42 days. The relationship between development of lesions and accumulated thermal time was described using a shifted cumulative gamma distribution model. The model provided good estimates of lesion development with r2> 0·92 for both cultivars. Base temperatures, below which the pathogen did not develop, were estimated from the model as approximately -2·4°C for the two cultivars. Latent period was estimated as being 250 and 301 degree-days above the estimated base temperature, when defined as time from inoculation to first lesion and time to 50% of maximal lesions, respectively, for cv. Riband. The values for cv. Apollo were similar, but with estimates of thermal time periods c. 5% higher. The relationship between mean temperature and inverse latent period, expressed as days either to first lesion or to 50% of maximal lesions, was best described by a linear regression with r2> 0·96 for both cultivars. The opportunity for plants to outgrow disease was reduced when prolonged periods of cold temperature occurred, because the base temperature for growth of the pathogen was less than that for the crop.	
1221	WIPPM	Luo Y, Shen ZR, Zeng SM, 1993. Risk analysis of disease epidemics on wheat by simulation studies. Agric. Sys. 43: 1, 67-89.	Dong JZ, 1988. A forecasting model (WIPPM-I) for integrated management of wheat stripe rust, leaf rust and powdery mildew. Beijing Agricultural University, Ph.D. thesis, 183 pp. (In Chinese with English abstract.)	Shen ZR, 1988. Weather simulation model for crop protection system management. Beijing Agricultural University, Ph.D. thesis, 132 pp. (In Chinese with English abstract.)	Zeng Tseng SM, Zhang WY, Xiao YY, 1981. A simulation model for wheat stripe rust. Puccinia striiformis West. Acta Agric. Univ. Beijing 7, 1-12 (In Chinese with English abstract).		Risk analysis on disease epidemics of wheat was studied by simulations, using a weather model (based on the weather generator developed by Shen (1988, Ph.D. thesis, Beijing Agricultural University)) and a multiple disease epidemic simulation model for wheat (Dong, 1988, Ph.D. thesis, Beijing Agricultural University). Monte-Carlo simulations were used to link these two models. Expected yield losses in wheat caused by three diseases under various weather conditions combined with different initial inoculum levels could be estimated. The information about the risk of disease epidemics was primarily obtained from analysis of the frequency distribution of expected simulated yield losses. Two sets of simulations were performed to study the risk of yield loss on wheat in general. Two additional sets of simulations were run for the Beijing and Gangu districts to provide examples of risk assessment tables in specific environments. Risk assessment tables could provide decision makers with a powerful tool to manage diseases.	
2361	M-ESB_Phenol	Lysyk TJ, 1989. Stochastic model of eastern spruce budworm (Lepidoptera: Tortricidae) phenology on white spruce and balsam fir. J. Econ. Entomol. 82: 4, 1161-1168.					Astochastic model of spruce budworm, Choristoneura fumiferana (Clemens), phenology on balsam fir, Abies balsamea (L.) Miller, and white spruce, Picea glauca (Moench) Voss, in northern Ontario was developed based on relationships between the proportion of budworms in each stage (second instar to adult) and accumulated degree-days (DD). Repeated calculations indicated that 8°C was a suitable threshold for degree-day calculations. Fifty percent of the population was in the second instar after 89 and 92 DD above 80C on balsam fir and white spruce, respectively. Peak occurrence of instars three, four, five, and six, and of pupae, occurred on balsam fir after 108, 154, 204, 295, and 413 DD, respectively; peak occurrence of the same stadia on white spruce occurred after 103, 138, 186, 256, and 370 DD. Fifty percent adult emergence occurred at 467 and 437 DD for balsam fir and white spruce. Tests of the model with independent data showed that it simulated spruce budworm development excellently. Model performance was superior compared with a previously published spruce budworm phenology model	

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1981	M-RWA-PopDyn	Ma ZS and Bechinski EJ, 2008. A survival-analysis-based simulation model for Russian wheat aphid population dynamics. Ecol. Model. 216: 3/4, 323-332.					A simulation model for Russian wheat aphid (RWA), Diuraphis noxia (Mordvilko), populations is built by integrating survival-analysis-based development and survivor functions and the same-shape reproduction distribution model in the framework of Leslie [Leslie, P.H., 1945. On the use of matrices in certain population mathematics. Biometrika 33, 183–212] matrix structure. Survival analysis is utilized to model both the development and survival of RWA populations, and the Cox (1972) proportional hazards model is fitted with the data sets from our laboratory observation of 1800 RWA individuals under 25 factorial combinations of five temperature regimes and five barley plant-growth stages. Rather than using simple age-specific survivor rates as in the traditional Leslie matrix, the survivor functions based on survival analysis describe age-specific, temperature and plant stage-dependent RWA survival probabilities. Similarly, a probability model from survival analysis to estimate the probability that an individual will reach mature adult stage is utilized to describe the development process; this makes the transition from nymphal stage to mature adult stage dependent on RWA age as well as temperature and plant-growth stage. Inspired by the same-shape distribution and rate-summation approach for modeling insect development, a similar approach for modeling insect reproduction under variable temperature is developed. This new same-shape reproduction distribution model incorporates individual variation in reproduction capability, as well as the effects of RWA age, temperature and plant-growth stage. Consequently, the same-shape reproduction distribution model replaces the simple age-specific fecundities in Leslie matrix model. To the best of our knowledge, thiswork is the first to introduce survival analysis to simulation modeling in entomology and ecology and also the first to integrate our newly developed same-shape reproduction distribution model int	A simulation model for Russian wheat aphid (RWA), <i>Diuraphis noxia</i> (Mordvilko), populations is built by integrating survival-analysis-based development and survivor functions and the same-shape reproduction distribution model in the framework of Leslie [Leslie, P.H., 1945. On the use of matrices in certain population mathematics. Biometrika 33, 183-212] matrix structure. Survival analysis is utilized to model both the development and survival of RWA populations, and the Cox (1972) proportional hazards model is fitted with the data sets from our laboratory observation of 1800 RWA individuals under 25 factorial combinations of five temperature regimes and five barley plant-growth stages. Rather than using simple age-specific survivor rates as in the traditional Leslie matrix, the survivor functions based on survival analysis describe age-specific, temperature and plant stage-dependent RWA survival probabilities. Similarly, a probability model from survival analysis to ! estimate the probability that an individual will reach mature adult stage is utilized to describe the development process; this makes the transition from nymphal stage to mature adult stage dependent on RWA age as well as temperature and plant-growth stage. Inspired by the same-shape distribution and rate-summation approach for modeling insect development, a similar approach for modeling insect reproduction under variable temperature is developed. This new same-shape reproduction distribution model incorporates individual variation in reproduction capability, as well as the effects of RWA age, temperature and plant-growth stage. Consequently, the same-shape reproduction distribution model replaces the simple age-specific fecundities in Leslie matrix model. To the best of our knowledge, this work is the first to introduce survival analysis to simulation modeling in entomology and ecology and also the first to integrate our newly developed same-shape <i>reproduction</i> distribution model into ap
761	M-RWA-DEV_PH	Ma ZS and Bechinski EJ, 2008. Developmental and Phenological Modeling of Russian Wheat Aphid (Hemiptera: Aphididae). Ann. Entomol. Soc. Am. 101: 2, 351-361.					We applied 14 insect development models, both deterministic and distributed, to describe Russian wheat aphid, Diuraphis noxia (Mordvilko) (Hemiptera: Aphididae), development and phenology. The Russian wheat aphid developmental data were from a laboratory experiment of 25 combinatorial treatments of Þve temperatures and Þve spring barley, Hordeum vulgare L., plant growth stages.Thedevelopmental times of 1,800 individual Russian wheat aphids at various stages were recorded in the experiment. We Þrst compared 11 deterministic development models and discussed some problems associated with the Þtting of these models. Not all nonlinear models could be fitted to every Russian wheat aphid stage. The results show that StinnerÕs model overall best Þt Russian wheat aphid developmental rate data, as judged by mean square error (MSE) and successful convergence. However, we observed a seemingly inescapable dilemma: when one introduces more complex nonlinear models to increase the descriptive power of models (with the hope that model parameters have some biological meanings), the more difÞcult it is to successfully Þt the model. Even if the model is fitted successfully, the values of the model parameters may well be beyond biologically meaningful ranges. Furthermore,	
3161	M-RWA_NLinDyn	Ma ZS and Bechinski EJ, 2009. An approach to the nonlinear dynamics of Russian wheat aphid population growth with the cusp catastrophe model. Entomological Research 39: 3, 175-181.					Many insect field populations, especially aphids, often exhibit irregular and even catastrophic fluctuations. The objective of the present study is to explore whether or not the population intrinsic rates of growth (rm) obtained under laboratory conditions can shed some light on the irregular changes of insect field populations. We propose to use the catastrophe theory, one of the earliest nonlinear dynamics theories, to answer the question. To collect the necessary data, we conducted a laboratory experiment to investigate population growth of the Russian wheat aphid (RWA), Diuraphis noxia (Mordvilko), in growth chambers. The experiment was designed as the factorial combinations of five temperatures and five host plantgrowth stages (25 treatments in total): 1800 newly born RWA nymphs arranged in the 25 treatments (each treatment with 72 repetitions) were observed for their development, reproduction and survival through their entire lifetimes. After obtaining the population intrinsic rates of growth (rm) from the experimental data under various environmental conditions, we built a cusp catastrophe model for RWA population growth by utilizing rm as the system state variable, and temperature and host plant-growth stage as control variables.	

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1521	M-WRust-Sudan	Mahir MA, 2000. Development of linear equations for predicting wheat rust epidemics in New Halfa, Sudan. The Eleventh Regional Wheat Workshop for Eastern, Central and Southern Africa, Addis Ababa, Ethiopia, 18-22 September 2000, 195-207.					Multiple regression analysis was used to develop equations predictive of the severity of leaf rust (Puccinia recondita f.sp. tritici) and stem rust (P. graminis f.sp. tritici) of bread wheat and to estimate weekly cumulative urediniospore numbers of both rust species in New Halfa region. Equations were generated for three overlapping periods to identify and quantify biological and meteorological variables which might provide clues of high predictive value for development of disease epidemics. Analysis of the combined data showed that the derived multiple regression models varied with prediction period, prediction duration and rust species. On the whole, progress in time (X₁) invariably significantly contributed to variation observed in rust severity. Other significant variables were found to be components of atmospheric humidity: minimum RH (X₄), maximum RH (X₅), and hours RH >80% (X₆), followed by maximum temperature (X₃) towards the end of the growing season but for leaf rust only. Minimum temperature (X₂) and wind speed (X₇), generally, did not significantly contribute to variation in rust severity. Simple linear regression analysis of overall disease severity revealed that leaf rust and combined rust exhibited highly significant and positive relationships with progress in time from 15 Jan. to 31 March, whereas stem rust had a non-significant negative relationship. The combined influence of three biological variables, namely progress in time (T), wheat growth stage (GS), and weekly trapped rust spore numbers (WSN), accounted for only 53 and 21.4% of the total variation in leaf rust and stem rust severity (DS), respectively. Studies with mechanical rust spore trapping (MRST) showed that 40 and 53.7% of the total variation in P. recondita, and P. graminis weekly trapped urediospore numbers (WSN) can be explained by a function involving: progress in time (T), wind direction (WD), and presen	
781	M-DON-NNMs	Mateo F, Gadea R, Mateo R, Medina A, Valle-Algarra FM, Jiménez M, 2008. Neural network models for prediction of trichothecene content in wheat. World Mycotoxin Journal 1: 3, 349-356.					Fusarium graminearum is a mould that causes serious diseases in cereals worldwide and that synthesises mycotoxins such as deoxynivalenol (DON), which can seriously affect human and animal health. Predicting the level of mycotoxin accumulation in food is very difficult, because of the complexity of the influencing parameters. In this work, we have studied the possibility of using artificial neural networks (NN) to predict DON level attained in F. graminearum wheat cultures taking as inputs the fungal contamination level of the cereal, the water activity as a measure of the available water for fungal growth in the cereal, the temperature and time. DON analysis was performed by gas chromatography with electron capture detection. The data matrix was used to train and validate various types of NN using MATLAB 7.0. The aim was to obtain a network that provided the best possible fit between predicted and target DON levels by minimising the mean-square error of test. Radial basis function-NNs attained lower errors and better generalisation than multi-layer perceptron networks to predict DON accumulation in wheat. This is the first time that NNs have been used to predict DON accumulation in wheat based on the studied factors.	
481	M-WKB-DI	Mavi HS, Jhorar OP, Sharma I, Gurmeet Singh, Mahi GS, Mathauda SS, Aujla SS, 1992. Forecasting Karnal bunt disease of wheat - a meteorological method. Cereal Res. Commun. 20: 1-2, 67-74.					Important meteorological elements are identified and included in a multiregression model for forecasting Neovossia [Tilletia] indica. Detailed analysis of historical data showed that the max. temp. for the 10th and 11th standard meteorological weeks (SMWs) and sunshine duration for weeks 9-11 are negatively related to disease intensity while evening RH during SMWs 9-11 and the number of rainy days for the 9th SMW are positively related. Regression analysis showed that these elements result in a coefficient of determination of 0.89 and DW value of 2.01. The ranges of the critical values of weather elements were also determined.	
2781	M-QFF_recover	Meats A and Fitt GP, 1987. Times for recovery from cold-torpor in the Queensland fruit fly Dacus tryoni: the relation to temperature during and after chilling. Entomol. Exp. Appl. 45: 1, 3-7.					Recovery time after experience of a given minimum temperature below torpor threshold is related to the value of that minimum, the length of time spent at that minimum, and the temperature prevailing during the recovery period above torpor threshold. A model can predict recovery time for flies experiencing a given temperature fluctuation if the length of time spent at the minimum is expressed as a proportion of LEso at that minimum. The model has applications in defining the optimal protocol for chilling insects for use in the Sterile Insect Release Method. The model was confirmed by experiments showing that it is likely that flies will recover from non-lethal frosts before ant predators become active.	

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2561	M-COLD-DACUTR	Meats A, 1976. Developmental and long-term acclimation to cold by the Queensland fruit-fly (Dacus tryoni) at constant and fluctuating temperatures. J. Insect Physiol. 22: 7, 1013-1019.						Dacus tryoni (Frogg.) was found to have exceptional powers of acclimation fo an insect. Thresholds for cold-torpor changed up to a maximum of 0.5 deg C/1 deg C change of acclimation temperature, an order of adaptation approaching the best in poikilotherms. Developmental acclimation could take place quickly; the critical period for this process corresponded to the last sixth of development time in the puparium. Post-teneral flies had a constant torpor threshold if maintained in the temperature regime of their developmental period. If changed to another regime, their threshold changed at a logarithmically declining rate towards the value that would be caused by developmental acclimation in that regime. The rate of post-teneral acclimation depended on both the current threshold and on the prevailing temperature but there was a maximum limit to the rate of cold-acclimation that could be induced. Post-teneral acclimation to cold could therefore be slow but this is no handicap in the field as it is induced at maximal rates by temperatures up to 13 deg C above the lowest attainable threshold. Acclimation for winter conditions therefore starts 2 to 3 months before such conditions occur. Changes in threshold and maintainance of constant thresholds in both constant and fluctuating conditions can be predicted by the same acclimation model, provided a modification is made to account for the fact that cold-acclimation at certain temperatures is faster when these are experienced intermittently than when they are experienced constantly.
2543	M-ECODIST-CERA	Meyer Mde, Robertson MP, Peterson AT, Mansell MW, 2008. Ecological niches and potential geographical distributions of Mediterranean fruit fly (Ceratitis capitata) and Natal fruit fly (Ceratitis rosa). J. Biogeogr. 35: 2, 270-281.					Aim To predict and compare potential geographical distributions of the Mediterranean fruit fly (Ceratitis capitata) and Natal fruit fly (Ceratitis rosa). Location Africa, southern Europe, and worldwide. Methods Two correlative ecological niche modelling techniques, genetic algorithm for rule-set prediction (GARP) and a technique based on principal components analysis (PCA), were used to predict distributions of the two fly species using distribution records and a set of environmental predictor variables. Results The two species appear to have broadly similar potential ranges in Africa and southern Europe, with much of sub-Saharan Africa and Madagascar predicted as highly suitable. The drier regions of Africa (central and western regions of southern Africa and Sahelian zone) were identified as being less suitable for C. rosa than for C. capitata. Overall, the proportion of the region predicted to be highly suitable is larger for C. capitata than for C. rosa under both techniques, suggesting that C. capitata may be tolerant of a wider range of climatic conditions than C. rosa. Worldwide, tropical and subtropical regions are highlighted as highly suitable for both species. Differences in overlap of predictions from the two models for these species were observed. An evaluation using independent records from the adventive range for C.	
2544	M-SDIN-DIABLO	Mitchell PD and Riedell WE, 2001. Stochastic dynamic population model for northern corn rootworm (Coleoptera: Chrysomelidae). J. Econ. Entomol. 94: 3, 599-616.					A stochastic dynamic population model for the complete life cycle of northern corn rootworm, Diabrotica barberi Smith & Lawrence, is described. Adult population dynamics from emergence to oviposition are based on a published single-season model for which temperaturedependent development and age-dependent advancement determine adult population dynamics and oviposition. Randomly generated daily temperatures make this model component stochastic. Stochastic hatch is 50 6 8%. A stochastic nonlinear density-dependent larval survival model is estimated using Þeld data from artiÞcial infestation experiments.Aregional model of corn phenology is estimated to incorporate the effect of dispersal on adult mortality. Random daily weather is generated using parameters for Brookings, SD. Model performance is evaluated with deterministic simulations, which show that the population converges to zero unless adult mortality is reduced by the availability of corn pollen from the regional model of corn phenology. Stochastic model performance is evaluated with stochastic daily weather, egg hatch, and larval survival in various combinations. Sensitivity analysis is conducted to evaluate model responsiveness to each parameter. Model results are generally consistent with published data.	
1224	M-DSSWeb	Moreau J-M and Maraite H, 2000. Development of an interactive decision-support system on a Web site for control of Mycosphaerella graminicola in winter wheat. Bulletin OEPP/EPPO Bulletin 30, 161-163.	Moreau JM and Maraite H, 1999. Integration of knowledge on wheat phenology and Septoria tritici epidemiology into a disease risk simulation model validated in Belgium. Aspects of Applied Biology 55, 1-6.				A decision-support system (DSS) has been developed in Belgium to help farmers and advisers to manage Mycosphaerella graminicola in winter wheat during stem elongation. The system calculates in real time the interactions between winter wheat and M. graminicola development to simulate disease progression in the canopy in order to guide field observations on the different leaf layers and determine the risks for the crop. It has been structured to run with individual field input and local hourly meteorological data. An interactive Internet version of the system has been developed to facilitate the delivery of information. It allows users to base their decisions on advice tailored to conditions in their own fields, as well as to recent and validated hourly local meteorological data that is regularly updated on the server computer.	

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163	M-WFHB-I	Moschini RC and Fortugno C, 1996. Predicting wheat head blight incidence using models based on meteorological factors in Pergamino, Argentina. Eur. J. Plant Pathol. 102, 211-218.	Moschini RC, Pioli R, Carmona M, Sacchi O, 2001. Empirical Predictions of Wheat Head Blight in the Northern Argentinean Pampas Region. Crop Sci. 41, 1541–1545.	Moschini RC, Carranza MR, Carmona MA, 2004. Meteorological-based predictions of wheat head blight epidemic in the Southern Argentinean Pampas Region. Cereal Res. Commun.. 32: 1, 45-52.	Carranza MR, Moschini RC, Kraan G, Bariffi JH, 2007. Examination of meteorology-based predictions of Fusarium head blight of wheat grown at two locations in the southern Pampas region of Argentina. Australas. Plant Pathol. 36:3, 305-308.		A computer program using the language and statistical procedures available from SAS (Statistical Analysis System) was written in order to identify the most highly correlated meteorological factors with the incidence of wheat head blight (caused byFusarium graminearum Schwabe) at Pergamino, in the humid pampeana region. Applying linear regression techniques, different models from simple up to a maximum of three independent variables were fitted to the data (1978–1990). The meteorological variables were processed in a time segment beginning eight days prior to the heading date (50% of emerged ears) and finishing when 530 degree days were accumulated (26–32 days). The number of two day periods with rainfall and relative humidity >81% in the first day and relative humidity = 78% in the second (NPPRH) was the variable that showed the strongest association with disease incidence (FI) (R^2=0.81). After examining the models in several ways (R^2, Adjusted R^2, PRESS statistic), two equations were selected: FI%=20.37 + 8.63 NPPRH – 0.49 DDXNT (R^2=0.86) and FI%=16.39 + 5.43 NPPRH – 0.45 DDXNT + 2.95 DPRH (R^2=0.886), in which DDXNT represents the daily accumulation of the residuals resulting from subtracting 9 to the minimum temperature values (<9 °C) and the exceeding amounts of maximum	
222	M-WBR-S	Moschini RC and Perez BA, 1999. Predicting wheat leaf rust severity using planting date, genetic resistance, and weather variables. Plant Dis. 83, 381-384.					Leaf rust epidemics of wheat, caused by Puccinia recondita f. sp. tritici, were analyzed for the 1972 to 1990 growing seasons. The disease severity values recorded for leaf rust in early and late bread-wheat planting dates at Pergamino were used to identify the best genetic and environmental predictors of disease severity. Leaf rust severity (early planting date) could be predicted (R^2 = 0.88) as a function of heat accumulation (base daily mean temperature >12°C), days with relative humidity >70% without precipitation, and a cultivar resistance index. For late planting date, the predictive value of meteorological variables decreased, while the importance of the resistance index increased over that found for the early seeded trials. In general, predicted and observed leaf rust severity levels agreed during 1994 to 1996 at Pergamino, and for trials (1991) that were grown at some distance from the area where the original data for model development were recorded.	
1223	M-STB-AUS	Murray G A, Martin R H, Cullis B R, 1990. Relationship of the Severity of Septoria tritici Blotch of Wheat to Sowing Time, Rainfall at Heading and Average Susceptibility of Wheat Cultivars in the Area. Aust. J. Agric. Res. 41, 307-315.	Murray GM, 1978. Distribution of Spetoria species on wheat in New South Wales. Aust. J. Agric. Res. 7, 44-45.	Murray GM, 1982. Yield losses in wheat associated with different levels of resistance to spackled leaf blotch (Mycosphaerella graminicola). Agronomy Australia, 242.	Murray G M and Brown J F,1987. The incidence and relative importance of wheat diseases in Australia. Australian Journal of Plant Pathology 16, 34-37.		The severity of epidemics of Septoria tritici blotch (STB) in wheat, caused by Mycosphaerella graminicola, was recorded for a 38-year period at Temora in southern New South Wales. The disease was rated as severe in 11 years, moderate in 1 1 and nil to light in 15, while very wet conditions prevented sowing in one year. The correlation of disease severity (S, where 0 =nil, 7 =very severe) with environmental and management factors was examined: the correlation was positive with days from sowing to heading and with rainfall (R - 4w, R-4w, mm) and the number of rainy days in the 4-week periods before and after heading; negative with the time of sowing (Ds, day of year) and with mean daily maximum temperature in the 4-week periods before and after heading. Days from sowing to heading were negatively correlated with sowing day, and rainy days and mean daily maximum temperature were correlated with total rainfall in the same time period. Addition ofthese terms did not significantly improve the prediction of severity. The cumulative sum of the recursive residuals from this regression showed a trend with time that was associated with the average susceptibility (SAV, where 1 =highly resistant, 7 =extremely susceptible) of wheat cultivars to STB grown in the district in the previous year. The second model showed that the reduction of the average susceptibility of cultivars grown in an area will reduce the severity of STB. It provided justification for minimum disease standards for cultivars to be grown where STB is potentially severe. Further, it explained the distribution of severity of STB in New South Wales.	
441	FusaProg	Musa T, Hecker A, Vogelgsang S, Forrer HR, 2007. Forecasting of Fusarium head blight and deoxynivalenol content in winter wheat with FusaProg. EPPO Bulletin 37, 283-289.					Fusarium head blight is one of the most serious cereal diseases of the world. Epidemics of Fusarium head blight can lead to a decline in grain quality and yield. In addition, grains often become contaminated with mycotoxins, which are harmful to humans and animals. In a field survey of winter wheat in Switzerland, Fusarium graminearum proved to be the most prevalent species responsible for head blight and deoxynivalenol the most common mycotoxin. To elucidate and quantify single or combined effects of cropping factors on F. graminearum infestation and to reduce the risk of mycotoxin contamination of wheat under conservation tillage, we developed the decision support system FusaProg. Our model takes into account the effects of cropping factors, previous crops, soil and straw management, as well as the F. graminearum susceptibility of the planted variety. These factors are used as driving variables and are combined with the prevailing weather conditions and growth stage in order to predict the deoxynivalenol content of a specific wheat plot before harvest. To use FusaProg as a threshold-based tool to control F. graminearum with optimized timing of fungicide applications, forecasts of deoxynivalenol contents are conducted during the flowering period. FusaProg is an Internet-based decision support system which not only provides	

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3081	M-WOS-HP	Nakamura K, 1984 Multiple regression analysis of scab occurrence of barley and wheat and scab forecasting in Hiroshima Prefecture. Bulletin of the Hiroshima Prefectural Agricultural Experiment Station 48, 49-66.						from CAB: The occurrence of scab [Gibberella zeae] on wheat barley was related to the amount of precipitation and temps. in Apr. and May, and the time of ploughing of the paddy fields where inoculum survived on rice stubble, according to the analyses of information obtained in 1955-80. Weather records 1889-1980 indicated that scab incidence increased with higher spring temps. and more days with >5 mm rain in May. The most severe epidemics were reported in 1890, 1923 and 1963 and these were correlated with favourable weather for infection during Apr. The conception of meteorological disaster was used to estimate forecast probability and economic loss and gain resulting from control measures taken as a result of disease forecasts.
2681	M-NCR_TempAge	Naranjo SE and Sawyer AJ, 1988. A temperature- and age-dependant simulation model of reproduction for the northern corn rootworm, Diabrotica barberi Smith and Lawrence (Coleoptera: Chrysomelidae). Can. Entomol. 120: 1, 1-17.					Based on data collected at seven constant temperatures, a temperature- and age-dependent model for reproductive development and oviposition by Diabrotica barberi Smith and Lawrence was developed. The model couples temperature-dependent rate and temperature- independent distribution models to represent the observed variability in developmental times for pre-reproductive, reproductive, and post-reproductive females. Using a cohort approach to maintain a physiological age structure, development was coupled with a temperature- and age-dependent model of oviposition. The model was validated at one constant-temperature and three variable-temperature regimes in the laboratory. The time spent in the pre-reproductive stage was slightly underestimated by the model, but the development of mature females and both the timing and magnitude of oviposition under fluctuating-temperature regimes were accurately predicted. The model was relatively insensitive to errors in estimation of the rate of development in the pre-reproductive stage but sensitive to errors in estimation of developmental rate of the reproductive stage and fecundity. Errors in input temperatures were found to be very important, stressing the need for accurately measuring temperature, The major driving variable. The model should be a valuable aid toward understanding oviposition by D. barberi in the field.	
1721	M-NCR_PopDyn	Naranjo SE and Sawyer AJ, 1989. A simulation model of northern corn rootworm,Diabrotica barberi Smith and Lawrence (Coleoptera: Chrysomelidae), population dynamics and oviposition: significance of host plant phenology. Can. Entomol. 121: 2, 169-191.	Naranjo SE and Sawyer AJ, 1989. Analysis of a simulation model of northern corn rootworm, Diabrotica barberi Smith and Lawrence (Coleoptera: Chrysomelidae), dynamics in field corn with implications for population management. Can. Entomol. 121, 194-207.				Based on field and laboratory research, a simulation model was developed that describes the within-season population dynamics and oviposition of adult northern com rootworm beetles, Diabrotica barberi Smith and Lawrence, in field com, Zea mays L. Particular emphasis was placed on the role of host plant phenology. Overall goals were to examine the contribution of insect dispersal to the dynamics of single fields, and provide a means ofexamining the factors influencing insecUplant synchrony and the relationship between adult abundance, oviposition, and crop phenology. The model is process-oriented and integrates component models for com phenology, and adult emergence, mortality, dispersal, reproductive development, and oviposition. Comparison of field data with simulations excluding dispersal generally indicated a net emigration of beetles from com fields on a season-long basis; however, the timing and magnitude of dispersal from fields were strongly influenced by the relative timing of com flowering, beetle sex, and the reproductive maturity of females. Simulation and field data were used to describe and estimate the parameters of a component model for dispersal incorporating these features. Various component models and the overall system model were validated against independent field data. The model	Based on field and laboratory research, a simulation model was developed that describes the within-season population dynamics and oviposition of adults of <i>Diabrotica barberi </i>in maize. Particular emphasis was placed on the role of host plant phenology. Overall goals were to examine the contribution of insect dispersal to the dynamics of single fields, and provide a means of examining the factors influencing insect/plant synchrony and the relationship between adult abundance, oviposition and crop phenology. The model is process-oriented and integrates component models for corn phenology, and adult emergence, mortality, dispersal, reproductive development and oviposition. Comparison of field data with simulations excluding dispersal generally indicated a net emigration of beetles from maize fields in New York on a season-long basis: however, the timing and magnitude of dispersal from fields were strongly influenced by the relative timing of maize flowering, beetle sex, and the reproductive maturity of females. Simulation and field data were used to describe and estimate the parameters of a component model for dispersal incorporating these features. Various component models and the overall system model were validated against independent field data. The model provided adequate prediction of

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2101	M-MONGA_DD	Naves P and Sousa Ede, 2009. Threshold temperatures and degree-day estimates for development of post-dormancy larvae of Monochamus galloprovincialis (Coleoptera: Cerambycidae). Journal of Pest Science 82: 1, 1-6.					Developmental thresholds and thermal requirements for development of post-dormancy larvae of Monochamus galloprovincialis (Olivier) (Cerambycidae; Monochamini) were studied at ten constant temperatures ranging from 7 to 35 C. The relationship between temperature and development duration in days was linear between 15 and 30 C (r2 = 0.98). The lower threshold for development was determined to be 12.2 ± 0.8 C and an average of 822 degree-days (DD) above that value was required for 50% adult emergence under laboratory conditions. The rate of larval development decreased above 30 C and the lethal upper threshold was between 32 and 35 C. Degree-day rate summation was initiated in the first of March and model predictions were validated with records of field emergence for the years 2001 to 2004. The modified sine wave predicted median emergence with an average error of 3.8 days from emergences in the field and a zero-day difference for two of the years. Model predictions were always within 10% of actual observed emergences. Predictions for early emergences (cumulative percentiles 1 and 10) were less accurate than predictions for median and late emergencies. The results suggest that a simple linear method driven by air temperatures can predict the emergence of M. galloprovincialis with sufficient accuracy to improve the pest management programmes currently implemented on the pine wilt disease affected zone in Portugal.	
2301	M-CRW_Emerg	Nowatzki TM, Tollefson JJ, Calvin DD, 2002. Development and validation of models for predicting the seasonal emergence of corn rootworm (Coleoptera: Chrysomelidae) beetles in Iowa. Environ. Entomol. 31: 5, 864-873.					Effective management of adult northern and western corn rootworms, Diabrotica barberi Smith & Lawrence and D. virgifera virgifera LeConte, respectively, requires knowledge of their emergence pattern so that scouting and adult insecticide applications can be accurately timed. The objective of this study was to develop and validate species- and sex-speciÞc models that reliably predicted adult corn rootworm emergence in Iowa. Prediction began from a bioÞx deÞned as the date of Þrst beetle emergence in a Þeld. The models were Þt with a 3-parameter Weibull function using emergence data collected in 57 Iowa cornÞelds over 5 yr. Models were validated with emergence data collected in 21additional Þelds from a separate year. A single Pherocon CRW Trap per Þeld was as effective as 13 emergence cages per Þeld at detecting the bioÞx. Air temperature degree-days accumulated from the emergence cage bioÞx explained 85% of the variability in total corn rootworm emergence over 5 yr. This model explained 89% and 83% of the variability in total beetle emergence observed in the validation year from the emergence cage and Pherocon CRW Trap bioÞxes, respectively. These models do not eliminate scouting for adult corn rootworms but should improve the scouting efÞciency by allowing growers to focus scouting to key periods, such as peak beetle emergence, when populations should be at their maximum abundance in the Þeld.	
1021	M-ST-WW	O'Callaghan JR, Dahab MH, Hossain AHMS, Wyseure GCL, 1994. Simulation of Septoria tritici-winter wheat interactions. Comput. Electron. Agric. 11: 4, 309-321.	Dahab MH and O'Callaghan J R, 1997. A Simulation Modelling Approach to the Management of Spray Treatments of Fungal Attacks on Wheat. Journal of Agricultural Engineering Research 66: 4, 287-293.				The progress of Septoria tritici infections in two varieties of winter wheat was observed at weekly intervals during the growing season 1991–1992. The disease moved upwards through the crop canopy and attacked the uppermost four leaves, which emerged in late April and May. The growth of the pycnidia population on a leaf is a function of thermal time and may be represented by a curve of exponential growth. A model simulating the development of S. tritici has been produced for the uppermost four leaves on the assumption that the infection is triggered by a rainfall event of at least 1 mm, visible symptoms follow an incubation period of 400 degree-days and that the subsequent growth of the pycnidia population on a given leaf is exponential. The model has been coupled dynamically with the SODCOM wheat model. Together they have shown that the reduction in final yield, which results from an outbreak of Septoria in a wheat crop, may be largely attributed to a reduction in the rate of gross photosynthesis. The coupled models may be used to predict dates of infection, quantify losses in yield and assist decision-making on disease management.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2621	M-OBL_Phen	Onstad DW, Reissig WH, Shoemaker CA, 1985. Phenology and management of the obliquebanded leafroller (Lepidoptera: Tortricidae) in apple orchards. J. Econ. Entomol. 78: 6, 1455-1462.					To manage properly the obliquebanded leafroller, Choristoneura rosaceana (Harris), its phenology must be understood in quantitative ter.ms. We measured the development and activity of all of its life stages in the laboratory, msectar~, and orc.hard. Some of these data were used to create a simple phenological model, whiCh was Simulated to produce a frequency distribution of hatching times for t~e su~~er generation.. Separate data sets were used to validate the model. We tested two msectIclde-treatment times suggested by this frequency distribution in commercial orchards. Results in~icated that a management policy requiring one application is both sufficient and robust with respec~ to .physiological time, although an application 400 degree-days (base 6.O"C) after the begmnmg of male moth flight may be safer than an earlier time	
381	M-GZ-ID	Paul PA, Lipps PE, Wolf E de, Shaner G, Buechley G, Adhikari T, Ali S, Stein J, Osborne L, Madden LV, 2007. A distributed lag analysis of the relationship between Gibberella zeae inoculum density on wheat spikes and weather variables. Phytopathology 97,1608-1624.					In an effort to characterize the association between weather variables and inoculum of Gibberella zeae in wheat canopies, spikes were sampled and assayed for pathogen propagules from plots established in Indiana, North Dakota, Ohio, Pennsylvania, South Dakota, and Manitoba between 1999 and 2005. Inoculum abundance was quantified as the daily number of colony forming units per spike (CFU/spike). A total of 49 individual weather variables for 24-h periods were generated from measurements of ambient weather data. Polynomial distributed lag regression analysis, followed by linear mixed model analysis, was used to (i) identify weather variables significantly related to log-transformed CFU/spike (the response variable; Y), (ii) determine the time window (i.e., lag length) over which each weather variable affected Y, (iii) determine the form of the relationship between each weather variable and Y (defined in terms of the polynomial degree for the relationship between the parameter weights for the weather variables and the time lag involved), and (iv) account for location-specific effects and random effects of years within locations on the response variable. Both location and year within location affected the magnitude of Y, but there was no consistent trend in Y over time. Y on each day was significantly and simultaneously related to weather variables on the day of sampling and on the 8 days prior to sampling (giving a 9-day time window). The structural relationship corresponded to polynomial degrees of 0, 1, or 2, generally showing a smooth change in the parameter weights and time lag. Moisture- (e.g., relative humidity-) related variables had the strongest relationship with Y, but air temperature- and rainfall-related variables also significantly affected Y. The overall marginal effect of each weather variable on Y was positive. Thus, local weather conditions can be utilized to improve estimates of spore density on wheat spikes around the time of flowering	
1501	M-TTApple1	Pearson RC, Aldwinckle HS, Seem RC, 1977. Teliospore germination and basidiospore formation in Gymnosporangium juniperi-virginianae: a regression model of temperature and time effects. Can. J. Bot. 55, 2832-2837.	Pearson RC, Aldwinckle HS, Seem RC, 1976. Basidiospore germination of Gymnosporangium juniperi-virginianae: model of time and temperature interactions. Proceedings of the American Phytopathological Society 3, 309 .				The influence of temperature on teliospore germination and basidiospore formation in Gymnosporangium juniperi-virginianae was studied in vitro. Teliospores germinated from 8 to 30°C. Germination was first observed after 12-28°C but longer periods were required at lower temperatures. Promycelia formed basidiospores by 4 h from 12 to 24°C nut not until 7 h at 8°C. Abortive germination of teliospores, without production of basiodiospores, occured from 26 to 30°C. No germination was observed from 2 to 6°C. Multiple regression analysis were performed and an equation relating germination of teliospores to temperature and time was formulated.	
201	M-WLB-PA-S	Pietravalle S,Shaw MW, Parker SR, Bosch F van den, 2003. Modeling of relationships between weather and Septoria tritici epidemics on winter wheat: a critical approach. Phytopathology 93, 1329-1339.					Two models for predicting Septoria tritici on winter wheat (cv. Riband) were developed using a program based on an iterative search of correlations between disease severity and weather. Data from four consecutive cropping seasons (1993/94 until 1996/97) at nine sites throughout England were used. A qualitative model predicted the presence or absence of Septoria tritici (at a 5% severity threshold within the top three leaf layers) using winter temperature (January/February) and wind speed to about the first node detectable growth stage. For sites above the disease threshold, a quantitative model predicted severity of Septoria tritici using rainfall during stem elongation. A test statistic was derived to test the validity of the iterative search used to obtain both models. This statistic was used in combination with bootstrap analyses in which the search program was rerun using weather data from previous years, therefore uncorrelated with the disease data, to investigate how likely correlations such as the ones found in our models would have been in the absence of genuine relationships.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2141	M-MPB_PopGrowth	Powell JA and Bentz BJ, 2009. Connecting phenological predictions with population growth rates for mountain pine beetle, an outbreak insect. Landsc. Ecol. 24: 5, 657-672.					It is expected that a significant impact of global warming will be disruption of phenology as environmental cues become disassociated from their selective impacts. However there are few, if any, models directly connecting phenology with population growth rates. In this paper we discuss connecting a distributional model describing mountain pine beetle phenology with a model of population success measured using annual growth rates derived from aerially detected counts of infested trees. This model bridges the gap between phenology predictions and population viability/growth rates for mountain pine beetle. The model is parameterized and compared with 8 years of data from a recent outbreak in central Idaho, and is driven using measured tree phloem temperatures from north and south bole aspects and cumulative forest area impacted. A model driven by observed south-side phloem temperatures and that includes a correction for forest area previously infested and killed is most predictive and generates realistic parameter values of mountain pine beetle fecundity and population growth. Given that observed phloem temperatures are not always available, we explore a variety of methods for using daily maximum and minimum ambient temperatures in model predictions.	
1961	M-TWD-ACC	Pria M dalla, Christiano RCS, Furtado EL, Amorim L, Bergamin Filho A, 2006. Effect of temperature and leaf wetness duration on infection of sweet oranges by Asiatic citrus canker. Plant Pathol. 55: 5, 657-663.	Lopes MV, Barreto M, Scaloppi É AG, Barbosa JC, Brunini O, 2008. Mapas de zonas de risco de epidemias e zoneamento agroclimático para o Cancro Cítrico no Estado de São Paulo. Summa Phytopathol. 34: 4, 349-353.				Asiatic citrus canker, caused by Xanthomonas smithii ssp. citri, formerly X. axonopodis pv. citri, is one of the most serious phytosanitary problems in Brazilian citrus crops. Experiments were conducted under controlled conditions to assess the influence of temperature and leaf wetness duration on infection and subsequent symptom development of citrus canker in sweet orange cvs Hamlin, Natal, Pera and Valencia. The quantified variables were incubation period, disease incidence, disease severity, mean lesion density and mean lesion size at temperatures of 12, 15, 20, 25, 30, 35, 40 and 42°C, and leaf wetness durations of 0, 4, 8, 12, 16, 20 and 24 h. Symptoms did not develop at 42°C. A generalized beta function showed a good fit to the temperature data, severity being highest in the range 30–35°C. The relationship between citrus canker severity and leaf wetness duration was explained by a monomolecular model, with the greatest severity occurring at 24 h of leaf wetness, with 4 h of wetness being the minimum duration sufficient to cause 100% incidence at optimal temperatures of 25–35°C. Mean lesion density behaved similarly to disease severity in relation to temperature variation and leaf wetness duration. A combined monomolecular-beta generalized model fitted disease severity, mean lesion density or lesion	
421	PUCTRI	Räder T, Racca P, Jörg E, Hau B, 2007. PUCREC/PUCTRI – a decision support system for the control of leaf rust of winter wheat and winter rye. EPPO Bulletin 37, 378-382.					During a three-year project from 2003 to 2006, two models have been developed to predict leaf rust (Puccinia recondite and P. triticina) occurrence and to simulate disease incidence progress curves on the upper leaf layers of winter rye (PUCREC) and winter wheat (PUCTRI). As input parameters the models use air temperature, relative humidity and precipitation. PUCREC and PUCTRI firstly calculate daily infection favourability and a cumulative infection pressure index and, in a second step, disease incidence is estimated. An ontogenetic model (SIMONTO) is used to link disease predictions to crop development. PUCREC and PUCTRI have been validated with data from 2001 to 2005. Both models give satisfactory results in simulating leaf rust epidemics and forecasting dates when action thresholds for leaf rust control are exceeded.	
1581	M-PAAMA	Ramirez-Legarreta MR and Jacobo-Cuellar JL, 1999. Structure of a model for mouldy core (Alternaria alternata f. sp. mali) of Red Delicious apple. Revista Mexicana de Fitopatologia 17: 1, 29-36.					Apple phenology, Alternaria population dynamics, weather data (maximum and minimum temperatures and rainfall) were recorded during 1996 and 1997 cycles; The operative management of apple orchards was evaluated, as well as moldy core epiphytotics on apple cv. Red Delicious. Data analysis allowed to design the model structure of the disease epiphytotic, which starts from the ubication of primary inoculum in spring, and activated by rainfall, sporulation ocurring at 43.4 ± 7 heat units (HU). After sporulation, open blossoms are needed for the pathogen to penetrate the host. For the first fruit symptoms to appear, 271 ± 32 HU must be accumulated after the first rainfall ocurred during full bloom. Thereafter, 611.45 ± 23.8 HU is the physiological interval for maximum injury index. It is estimated that out of the total diseased fruits, 47% fall feeding back the system as primary inoculum, while the remaining 53% are marketed as healthy fruit.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2041	M-TWD-WLR-LA	Rao KVS, Berggren GT, Snow JP, 1990. Characterization of wheat leaf rust epidemics in Louisiana. Phytopathology 80: 4, 402-410.						From CAB: Two experiments were conducted to study the effect of time of inoculation on leaf rust [Puccinia recondita] progress and to study the spatiotemporal spread of leaf rust in Baton Rouge, LA, during the 1986-87 and 1987-88 wheat-growing seasons. Epidemics were generated by sequential inoculation of different plots of a leaf rust-susceptible cultivar, McNair 1003, at 15-day intervals from 1 Feb. to 15 Mar. 1987, and from 1 Dec. 1987 to 1 Mar. 1988. Depending on the time of inoculation, the incubation period after inoculation varied from 8 to 18 days and appeared to be a function of the prevalent temp. Early inoculations resulted in long, apparently stationary periods of development and greater areas under the disease progress curve (AUDPC). Leaf rust increase in all the plots occurred at the same time in Mar. The average apparent infection rates (r) of the epidemics were significantly different for different dates of inoculation. The r-values varied from 0.076 to 0.153/day during 1986-87 and from 0.047 to 0.157/day during 1987-88. Leaf rust severity was highly correlated with cumulative degree days (>20 degrees C) following inoculation. The spatial and temporal spread of leaf rust was studied on the cultivars Rosen, McNair
1001	EPISEPT	Rapilly F and Jolivet E, 1976. Construction d'un modèle (EPISEPT) permettant la simulation d'une épidémie de Septoria nodorum BERK. sur blé. Revue de Statistique Appliquée 3, 31–60.	Jolivet E, 1981. Prévision de l'importance d'une épidémie de septoriose du blé à Septoria nodorum. Agronomie 1:10, 839-844.					An attempt to construct a model of S. [Leptosphaeria] nodorum infection is described. The events constituting the epidemic are described and interpreted analytically. Some results obtained by transcription on a computer are presented.
2545	M-COLD-DENCPO	Regniere J and Bentz B, 2007. Modeling cold tolerance in the mountain pine beetle, Dendroctonus ponderosae. J. Insect Physiol. 53: 6, 559-572.					Cold-induced mortality is a key factor driving mountain pine beetle, Dendroctonus ponderosae, population dynamics. In this species, the supercooling point (SCP) is representative of mortality induced by acute cold exposure. Mountain pine beetle SCP and associated cold-induced mortality fluctuate throughout a generation, with the highest SCPs prior to and following winter. Using observed SCPs of field-collected D. ponderosae larvae throughout the developmental season and associated phloem temperatures, we developed a mechanistic model that describes the SCP distribution of a population as a function of daily changes in the temperature-dependent processes leading to gain and loss of cold tolerance. It is based on the changing proportion of individuals in three states: (1) a non coldhardened, feeding state, (2) an intermediate state in which insects have ceased feeding, voided their gut content and eliminated as many ice-nucleating agents as possible from the body, and (3) a fully cold-hardened state where insects have accumulated a maximum concentration of cryoprotectants (e.g. glycerol). Shifts in the proportion of individuals in each state occur in response to the driving variables influencing the opposite rates of gain and loss of cold hardening. The level of cold-induced mortality predicted by the model and its relation to extreme winter temperature is in good agreement with a range of field and laboratory observations. Our model predicts that cold tolerance of D. ponderosae varies within a season, among seasons, and among geographic locations depending on local climate. This variability is an emergent property of the model, and has important implications for understanding the insect's response to seasonal fluctuations in temperature, as well as population response to climate change. Because cold-induced mortality is but one of several major influences of climate on D. ponderosae population dynamics, we suggest that this model be integrated with others simulating	
2341	M-SB_BTEfficay	Regniere J and Cooke B, 1998. Validation of a process-oriented model of Bacillus thuringiensis variety kurstaki efficacy against spruce budworm (Lepidoptera: Tortricidae). Environ. Entomol. 27: 4, 801-811.					A model simulating the efficacy of Bacillus thuringiensis variety kurstaki Berliner against populations ofthe spruce budworm, Charistoneurafumiferana (Clemens), on balsam fir, Abies balsamea L., was validated with extensive field data. The model, a detailed description of the interactions between the insect and its pathogen, requires as input daily minimum and maximum air temperature, spray deposit measurements (product potency, droplet density, diameter spectrum), initial budworm density and stage-specific survival rates of untreated populations. The model simulated the efficacy of treatments in 24 plots that received single or double applications of Foray 48B and 76B at rates of30 and 50 BIU/ ha. Observations also were made in 5 control (untreated) plots. The model accurately predicted both foliage protection and population reduction, and constitutes a valid tool for decision making concerning optimal application rates, atomization, and timing with respect to control objectives. Comparisons between simulated and observed patterns of development, defoliation and population reduction indicated several areas where additional knowledge on the interactions between B. thuringiensis and spruce budworm would be beneficial. In particular, a better understanding of the influence of plant quality on feeding, development and behavior of spruce	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2943	M-SB_Phenol	Regniere J, 1982. A process-oriented model of spruce budworm phenology (Lepidoptera: Tortricidae). Can. Entomol. 114: 9, 811-825.					In this paper a process-oriented model of spruce budworm phenology is developed which produces simulations comparing favorably with observed phenological trends taken from literature. Major features of this model include: (1) non-linear descriptions of temperature-dependent development of larval instars and pupal stadium; (2) three sources of variability in development rates (intrinsic, sexrelated, and microclimatic); and (3) generation of daily temperature cycles for four microhabitats from input min-max air temperature data.	
1701	M-SBOvip	Regniere J, 1983. An oviposition model for the spruce budworm, Choristoneura fumiferana (Lepidoptera: Tortricidae). Can. Entomol. 115: 10, 1371-1382.					A process-oriented model was developed to describe the oviposition of the spruce budworm, Choristoneurafumiferana (Clem.), on an individual and a population basis. The model simulates the effects of temperature on female longevity, oogenesis, and oviposition. The model is structured for ease of incorporation of additional processes such as emigration, immigration, mating, and other behavioral reductions in oviposition activity. Simulation results, at both the individual and the population levels, are compared with laboratory and field data. This model is an element of a model of spruce budworm biology currently under development but, by itself, can be used to study the effects of temperature and dispersal on the fecundity of spruce budworm populations.	Partly from data collected on white spruce (<i>Picea glauca</i>) and balsam fir (<i>Abies balsamea</i>) in Ontario in 1982, a process-oriented model was developed to describe the oviposition of <i>Choristoneura fumiferana </i>(Clem.) on an individual and a population basis. The model simulates the effects of temperature on female life-span, oogenesis and oviposition. It is structured for ease of incorporation of additional processes such as emigration, immigration, mating and other behavioural reductions in oviposition activity. Simulation results, at both the individual and population levels, are compared with laboratory and field data.
2224	M-WSB_Dev	Reichenbach NG and Stairs GR, 1984. Response of the western spruce budworm (Lepidoptera: Tortricidae) to temperature and humidity: developmental rates and survivorship. Environ. Entomol. 13: 2, 611-618.					The variability in the developmental rates for the embryos, larvae, and pupae of the western spruce budworm, Choristoneura oCcidentalis, was skewed and was well described by a gamma probability density function. At extreme temperatures, the shapes of the frequency distributions for the embryos and pupae were not unimodal, suggesting the presence of thermal biotypes. Variability increased markedly towards the temperature extremes (15 and 31°C) and was greater for female than for male larvae. The shapes of the frequency distributions for larvae terminating diapause ranged from a skewed curve for second-instar larvae held in diapause at OOC to a negative exponential curve for larvae held at 5°C. A Monte Carlo simulation model showed that the probability of synchronous emergence of male and female moths was relatively constant (ca. 66%) over a range of average minimum/maximum temperatures. During the larval developmental period, average minimum/ maximum ranged from 2.3/18.1 to 6.0/21.0"C. For the pupae developmental period, average minimum/maximum temperatures ranged from 6.0/21.0 to 11.4/27.1°C. Above these temperatures, the probability of synchronous emergence decreased	
2262	M-WSB_DevRate	Reichenbach NG and Stairs GR, 1984. Response of the western spruce budworm, Choristoneura occidentalis (Lepidoptera: Tortricidae), to temperature: the stochastic nature of developmental rates and diapause termination. Environ. Entomol. 13: 6, 1549-1556.					The variability in the developmental rates for the embryos, larvae, and pupae of the western spruce budworm, Choristoneura oCcidentalis, was skewed and was well described by a gamma probability density function. At extreme temperatures, the shapes of the frequency distributions for the embryos and pupae were not unimodal, suggesting the presence of thermal biotypes. Variability increased markedly towards the temperature extremes (15 and 31°C) and was greater for female than for male larvae. The shapes of the frequency distributions for larvae terminating diapause ranged from a skewed curve for second-instar larvae held in diapause at OOC to a negative exponential curve for larvae held at 5°C. A Monte Carlo simulation model showed that the probability of synchronous emergence of male and female moths was relatively constant (ca. 66%) over a range of average minimum/maximum temperatures. During the larval developmental period, average minimum/ maximum ranged from 2.3/18.1 to 6.0/21.0"C. For the pupae developmental period, average minimum/maximum temperatures ranged from 6.0/21.0 to 11.4/27.1°C. Above these temperatures, the probability of synchronous emergence decreased.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2261	M-AMF_Emerg	Reissig WH, Barnard J, Weires RW, Glass EH, Dean RW, 1979. Prediction of apple maggot fly emergence from thermal unit accumulation. Environ. Entomol. 8: 1, 51-54.					The minimum temperature threshold for the development of apple maggot pupae, Rhagoletis pomonella, was 6.4°C. From 1951-75 the 1st flies emerged in cages over infested apples on the avg on June 15 near Highland, NY and on June 23 in Geneva, NY. The avg accumulated air temperature thennal units (T.V. 's) from Mar. I using a threshold of 6.4°C until 1st emergence were 614±53 and 641±48, respectively, at the 2 locations. The annual deviations between the actual first emergence and the date when the avg T.V. 's were accumulated ranged from 1-8 days with an avg of 3.5 at Geneva and from 1-14 days with an avg of 5.7 days at Highland. From 1975-77 the mean T.V. accumulation and the 99% confidence interval developed at Geneva was used to predict emergence in 5 locations in Wayne Co. The deviations between the observed emergence and dates in which the appropriate number of T.V.'s was accumulated averaged 3.5 and 0.8 days, respectively	
2342	M-PC_Ovip	Reissig WH, Nyrop JP, Straub R, 1998. Oviposition model for timing insecticide sprays against plum curculio (Coleoptera: Curculionidae) in New York State. Environ. Entomol. 27: 5, 1053-1061.					Plum curculio, Conotrachelus nenuphar (Herbst), feeding and oviposition on apples during spring was measured for 3yr in a heavily infested orchard in New York State. Alogistic model was formulated to relate cumulative fruit injury to cumulative heat units (degree-days base 10°C [DDIOl) following petal fall. Cumulative plum curculio injury was well described by the model in the trees from which data for the model were collected. However, injury progressed faster and ended earlier in smaller trees at the same site and at a different site, probably because of differences in tree architecture. Field trials showed that protection of the fruit via insecticide residue was no longer necessary after the model predicted that 40% ofthe cumulative plum curculio oviposition and feeding cycle had been completed (171 DDIO after petal fall). Based on historical weather records, use of the model to schedule insecticide treatments would save 1insecticide application nearly halfthe time compared with a standard of3insecticide applications. Adelay between initial plum curculio feeding and oviposition, which coincides with the petal fall, phenophase, and steadily increasing damage, which is influenced by temperatures after petal fall was observed. The effectiveness of delaying insecticide treatments until the rate of plum curculio damage was rapidly	
981	Septo3D	Robert C, Fournier C, Andrieu B, Ney B, 2008. Coupling a 3D virtual wheat (Triticum aestivum) plant model with a Septoria tritici epidemic model (Septo3D): a new approach to investigate plant–pathogen interactions linked to canopy architecture. Funct. Plant Biol. 35, 997–1013.	Rapilly F and Jolivet E, 1976. Construction d'un modèle (EPISEPT) permettant la simulation d'une épidémie de Septoria nodorum BERK. sur blé. Revue de Statistique Appliquée 3, 31–60.	Evers JB,Vos J, Fournier C, Andrieu B, Chelle M,Struik PC, 2005. Towards a generic architectural model of tillering in Gramineae, as exemplified by spring wheat (Triticum aestivum). New Phytol. 166, 801–812.	Baret F, Andrieu B, Steven MD, 1993. Gap frequency and canopy architecture of sugar-beet and wheat crops. Agric. For. Meteorol. 65, 261–279.		This work initiates a modelling approach that allows us to investigate the effects of canopy architecture on foliar epidemics development. It combines a virtual plant model of wheat (Triticum aestivum L.) with an epidemic model of Septoria triticiwhich is caused by Mycosphaerella graminicola, a hemi-biotrophic, splashed-dispersed fungus. Our model simulates the development of the lesions from the infected lower leaves to the healthy upper leaves in the growing canopy. Epidemics result from the repeated successions of lesion development (during which spores are produced) and spores dispersal. In themodel, canopy development influences epidemic development through the amount of tissue available for lesion development and through its effects on rain penetration and droplets interception during spore dispersal. Simulations showthat the impact of canopy architecture on epidemic development differs between canopy traits and depends on climate. Phyllochron has the strongest effect, followed by leaf size and stem elongation rate.	
2921	M-FTC_Outbreak	Roland J, Mackey BG, Cooke B, 1998. Effects of climate and forest structure on duration of forest tent caterpillar outbreaks across central Ontario, Canada. Can. Entomol. 130: 5, 703-714.					We examined the effect of forest structure and climate on large-scale and long-term patterns of outbreaks of forest tent caterpillar, Malacosoma disstria Hbn., across central Ontario. This was done using previously published data on outbreak duration and forest heterogeneity, combined with high-resolution climatic data simulated by the recently developed Ontario Climate Model. Our analysis, which eliminates some of the spatially confounding effects of forest structure and climate, suggests that both the predicted long-term temperature minimum for the coldest month and the predicted growing degree-days in the first 6 weeks of the growing season are important determinants of outbreak duration, with colder weather being associated with shorter outbreaks. Forest heterogeneity accounts for more variation in outbreak duration than either of the climatic variables	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
3021	SIMSEPT	Rosberg D, Kluge E, Jorg E, 2003. SimSept - a new forecasting model for the incidence of Septoria tritici and Septoria nodorum. Gesunde Pflanzen, 55 Jahrg., Heft 1, 8-12.					SIMSEPT is a new simulation model to predict the incidence and development of Septoria tritici and Septoria nodorum in winter wheat. SIMSEPT has been developed by order of ZEPP (Central Institution for Decision Support Systems in Crop Protection) to support governmental crop protection services in their warning service activities. The model simulates the epidemic development of both Septoria species by using temperature, relative humidity and precipitation as input variables and indicates the incidence in a region represented by a meteorological station. On March 1, April 1 and May 1 of each year long-term forecasts are given on anticipated disease development until mid-June as well as on the necessity of fungicide treatments to control the leaf blotch diseases. As Septoria epidemics develop in “sudden outbreaks”, knowledge of infection dates is important for planning curative fungicide treatments. These dates are calculated by SIMSEPT and are supplemented by information on crop ontogenesis (BBCH-stages) and the actual levels of disease severity from April 1 onwards. From this information recommendations on timing of fungicide treatments can be derived. A total of 132 disease progress curves for S. tritici and 36 for S. nodorum from 1995–2001 were compared to disease development simulated	
261	M-WPM-Index	Rossi V and Giosuè S, 2002. Un modello previsionale per i trattamenti fungicidi contro il mal bianco del frumento. Atti II Giornate di studio “Metodi numerici, statistici e informatici nella difesa delle colture agrarie e delle foreste: ricerca e applicazioni”, Pisa, Italy, 2002. In: Notiziario sulla Protezione delle Piante, 15 (N.S.), 301-307.	Rossi V and Giosuè S, 2003. A dynamic simulation model for powdery mildew epidemics on winter wheat. Bulletin OEPP 33, 389-396.				A dynamic model simulating powdery mildew epidemics on wheat was used to calculate a disease index able to forecast the time of fungicide sprays for controlling the disease. The index accounted for the effect of meteorological conditions on spore production and infection. It was validated using field data not used in its elaboration; it resulted accurate and robust in signalling, 5 to 12 days in advance, the time when the epidemics reached the threshold for fungicide application.	
243	POWDEP	Rossi V and Giosuè S, 2003. A dynamic simulation model for powdery mildew epidemics on winter wheat. Bulletin OEPP 33, 389-396.	Rossi V, Giosuè S, Racca P, 2000. Modelling the effect of weather on wheat powdery mildew. Acta Phytopathol. Entomol. Hung. 35, 323–332.	Rossi V, Giosuè S, Racca P, 2000. Relationships between epidemiological parameters of Erysiphe graminis f. sp. tritici under fluctuating weather conditions. Acta Phytopathol. Entomol. Hung. 35, 333-341.			A system dynamic model for epidemics of Blumeria graminis (powdery mildew) on wheat was elaborated, based on the interaction between stages of the disease cycle, weather conditions and host characteristics. The model simulates the progress of disease severity, expressed as a percentage of powdered leaf area, on individual leaves, with a time step of one day, as a result of two processes: the growth of fungal colonies already present on the leaves and the appearance of new colonies. By means of mathematical equations, air temperature, vapour pressure deficit, rainfall and wind are used to calculate incubation, latency and sporulation periods, the growth of pathogen colonies, infection and spore survival. Effects of host susceptibility to infection, and of leaf position within the plant canopy, are also included. Model validation was carried out by comparing model outputs with the dynamics of epidemics observed on winter wheat grown at several locations in northern Italy (1991–98). Simulations were performed using meteorological data measured in standard meteorological stations. As there was good agreement between model outputs and actual disease severity, the model can be considered a satisfactory simulator of the effect of environmental conditions on the progress of powdery mildew epidemics.	
321	FHB-wheat	Rossi V, Giosuè S, Pattori E, Spanna F, Del Vecchio A, 2003. A model estimating the risk of Fusarium head blight on wheat. EPPO Bulletin 33, 421-425.	Rossi V, Giosuè S, Pattori E, Languasco L, 2001. Risk of Fusarium head blight on wheat: a preliminary model. In: Proceedings of the 11th Congress of the Mediterranean Phytopathological Union, Evora (Portugal), Andalus Academic Publishing, Portugal, 46-48.	Rossi V, Giosuè S, Delogu G, 2003. A model estimating risk for Fusarium mycotoxin in wheat kernels. Aspects of Applied Biology 68, 229-234.	Rossi V, Giosuè S, Girometta B, Cigolini M, 2004. Dynamic simulation of Fusarium Head Blight epidemics. In: Proceedings of the 2nd International Symposium on Fusarium Head Blight, Orlando, Florida (USA), Michigan State University, East Lansing (MI) Vol. 2, 494-497.		A dynamic simulation model for the risk of Fusarium head blight on wheat was elaborated based on systems analysis. The model calculates a daily infection risk based on sporulation, spore dispersal and infection of host tissue of the four main species causing the disease (Gibberella zeae, Fusarium culmorum, Gibberella avenacea, Monographella nivalis). Spore yield and dispersal are calculated as functions of temperature, rainfall and relative humidity, while the main factors affecting the infection rate are temperature, wetness and the host growth stage. The model also calculates a risk for mycotoxin production by G. zeae and F. culmorum in the infected head tissue. First validations against field data, collected in some wheat-growing areas in northern Italy and not used in model elaboration, produced satisfactory results.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
341	M-WFHB-DSS	Rossi V, Giosuè S, Terzi V, Scudellari D, 2007. A decision support system for Fusarium head blight on small grain cereals. EPPO Bulletin 37, 359-367.	Rossi V, Giosuè S, Pattori E, Spanna F, Del Vecchio A (2003) A model estimating the risk of Fusarium head blight on wheat. EPPO Bulletin 33, 421-425.				A DSS was elaborated to determine the level of risk for mycotoxin accumulation in small grain cereals during the growing season and to support different management actions along the cereal production chain. The DSS is based on a discriminant analysis carried out on a representative data set on the presence of deoxinivalenol in winter-sown bread wheat, durum wheat and barley grown in different areas of Emilia-Romagna (northern Italy) between 2002 and 2004. Three to five levels of proneness to Fusarium head blight were defined for six influencing factors (weather conditions, growing area, host species and variety, previous crop and type of soil tillage before sowing), each level having its own coefficient, and linearly combined in an equation of risk (R). A value of R can be then calculated for any plot using information at both regional (weather conditions and growing area) and plot-specific (host and cropping practices) levels. R ranges between - 3.86 and 4.43 with four risk levels: low (R = –2), intermediate (–2 < R = –0.44), high (–0.44 < R = 1.2), and very high (R > 1.2). Different management actions are suggested based on the level of R of the plot. The DSS was satisfactorily validated using data from many plots other than those used in its elaboration.	
282	RUSTDEP	Rossi V, Racca P, Giosue' S, Pancaldi D, Alberti I, 1997. A simulation model for the development of brown rust epidemics in winter wheat. Eur. J. Plant Pathol. 103, 453-465.					A model simulating the progress of Puccinia recondita severity, expressed as a percentage of rusted leaf area (both as average and its 95% confidence interval) on individual wheat leaves over the course of a growing season, with a time step of one day, was elaborated using laboratory and field data from literature. Data on the stages of each infection cycle (uredospore germination, penetration, latency, uredium eruption and infectiousness) were transformed into model parameters by curve fitting, Montecarlo stochastic procedures, corrections and empirical assumptions. Data on host growth, like the timing of all phenological stages, the dynamic of the green area of each leaf from appearance to complete senescence, and tillering were obtained from a specific sub-model. Model validation was performed on actual data not used in model building and representing a wide range of conditions (several winter wheat cultivars grown at eight locations in northern Italy between 1990 and 1994) by using subjective, non-parametric and parametric tests: it revealed a satisfactory agreement between the data simulated by the model and actual data.	
301	M-WBR-AS	Rossi V, Racca P, Giosue' S, Pancaldi D, Bottazzi R, 1997. An advisory system for the control of brown rust on winter wheat in northern Italy. In: Dehne HW, Adam G, Diekmann M, Frahm J, Mauler-Machnik A, van Halteren P. (Eds.) Diagnosis and identification of plant pathogens (Developments in Plant Pathology) . Proceedings of the 4th International Symposium of the European Foundation for Plant Pathology, Bonn, Germany, 9-12 September 1996. Kluwer, Dordrecht, 281-284.	Rossi V, Racca P, Pancaldi D, Alberti I, 1996. Appearance of Puccinia recondita f.sp. tritici on winter wheat: a simulation model. EPPO Bulletin 26, 555-566.	Rossi V, Racca P, Giosue' S, Pancaldi D, Alberti I, 1997. A simulation model for the development of brown rust epidemics in winter wheat . Eur. J. Plant Pathol. 103, 453-465.				(from CAB) A combination of 3 simulation models, WHEGROSIM to simulate growth of winter wheat, RUSTPRI to determine when brown rust (Puccinia recondita) symptoms appear, and RUSTDEP to simulate the progress of rust epidemics, were combined and tested in field conditions using hourly data on temperature, RH, leaf wetness and rainfall to develop an advisory system for the control of brown rust. Field tests were carried out during 1994-96. It was concluded that it was possible to obtain satisfactory simulations of both the onset and progress of brown rust on winter wheat.

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
281	RUSTPRI	Rossi V, Racca P, Pancaldi D, Alberti I, 1996. Appearance of Puccinia recondita f.sp. tritici on winter wheat: a simulation model. EPPO Bulletin 26, 555-566.					A simulation model was developed for the appearance of leaf rust (Puccinia recondita f.sp. tritici) on winter wheat. The model was based on the uredospore cycle. Relationships between weather, host and infection processes (such as uredospore germination, germ-tube penetration, length of latent period, uredia eruption) were transformed into model parameters by curve fitting, corrections and empirical assumptions. The model was validated by a backward method: model outputs were compared with actual data collected at eight sites in northern Italy over 4 years. The model gave a good simulation of the establishment of primary infections of leaf rust: an agreement between disease appearance in the field and model outputs was found in 93% of the 28 cases in which rust appeared. Air temperature and leaf wetness were the limiting factors for infection establishment. A prevalent (96% of cases) association between rain and infection showed that uredospores causing infections were washed onto the ground by rainfall.	
2601	M-BWR_Emerg	Rummel DR and Hatfield JL, 1988. Thermal-based emergence model for the bollworm (Lepidoptera: Noctuidae) in the Texas high plains. J. Econ. Entomol. 81: 6, 1620-1623.					Winter survival and spring emergence data for bollworm, Heliothis zea (Boddie), were collected over a 6-yr period and were used to develop a heat unit emergence model for the Texas High Plains. The driving force for H. zea emergence is soil temperature at the IO-cm level. Heat units were calculated using maximum and minimum IO-cm soil temperature and a threshold temperature of 23°C. The fit between accumulated heat units and cumulative emergence was linear. The agreement between predicted and actual emergence was good even though cumulative emergence varied among years in the dates of first and last emergence and the length of the emergence period. The results of this study indicate the developed model to be capable of responding to a variety of environmental conditions.	
2901	M-ForecastMod-IR	Safaie N and Alizadeh A, 2006. Evaluation of temporal disease progress models of wheat fusarium head blight and developing a forecasting model for Golestan Province. Iran. J. Plant Pathol. 42: 4, Pe597-Pe617, En169-En175.					Epidemiological Studies were conducted during 2003-2004 to find the best model which describes disease progress of wheat head blight. Analyses of disease progress data under mist and with artificial inoculation showed that for Atrak, Falat, Koohdasht, Pasteur and Tajan cultivars, the logistic model and for Zagros, the monomolecular model were suitable. For Koohdasht and Pasteur cultivars the log-logistic model was as suitable as logistic model. Under mist system and without artificial inoculation, for Falat, Pasteur and Zagros cultivars logistic and log-logistic models were the best models describing disease progress data. Out of mist system and with artificial inoculation for Falat and Tajan cultivars logistic and log-logistic models were fitted the best. For other cultivars none of studied epidemiological models were fitted due to insignificant disease progress on them. Accordingly, logistic and log-logistic models are considered as the most suitable model for disease progress on Falat, Tajan, Zagros, Koohdasht, Atrak and Pasteur cultivars under field condition. In order to develop a disease forecasting model for Fusarium head blight (FHB) of wheat, data for disease severity in artificially inoculated and naturally infected fields in Golestan province during 1997- 2000 were recorded. In addition, meteorological data for the same period from Experimental Station of Araghi- Mahaleh, Gorgan, were obtained and used. This model employs environmental factors including daily precipitation (Pm) and temperature (T) for seven days prior to anthesis and developed by multivariate regression analysis. This regression model considers environmental factors (T and Pm) as independent variables; and	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2701	M-MPB_Disper	Safranyik L, Silversides R, McMullen LH, Linton DA, 1989. An empirical approach to modelling the dispersal of the mountain pine beetle (Dendroctonus ponderosae Hopk.) (Col., Scolytidae) in relation to sources of attraction, wind direction and speed. J. Appl. Entomol. 108: 5, 498-511.					An empirical method was developed for predicting the directional distribution of mountain pine beetles (Dendroctonus ponderosae Hopk.) responding to attractive semiochemicals. An emergence model relates relative hourly beetle emergence to mean hourly ambient temperature, a daily rhythm of emergence, and daily total number of emerged beetles. Trap catches were used as a relative measure of emergence. A dispersal model relates the relative directional distribution of dispersing beetles, searching for sources of attraction, to mean hourly wind direction and speed, and relative hourly abundance of dispersing beetles. The latter model includes a deflection angle relative to mean wind direction to allow for an assumed crosswind movement by searching beetles. Both models gave good fit to the experimental data, but wind speed had negligible effect on the fit of the model for relative directional distribution of beetles. When tested on independent data, the dispersal model gave good predictions of the numbers of self-marked mountain pine beetles of three different colours trapped in passive traps at four trapping sites. This model also gave a reasonable prediction of the general directional distribution of attacked trees relative to the brood trees. More extensive testing is suggested to further explore the model structure and performance. Numbers of self-marked mountain pine beetles trapped by time period, location, and height were also analysed and discussed in relation to flight behaviour of beetles.	
2121	M-ESB_Phen	Santolamazza-Carbone S, Rodriguez-Illamola A, Cordero Rivera A, 2006. Thermal requirements and phenology of the Eucalyptus snout beetle Gonipterus scutellatus Gyllenhal. J. Appl. Entomol. 130: 6/7, 368-376.					Laboratory experiments and field surveys were carried out to study the thermal requirements and phenology of the Eucalyptus snout beetle Gonipterus scutellatus (Curculionidae) and its parasitoid, Anaphes nitens (Mymaridae). Developmental times were recorded for G. scutellatus life stages: egg to first instar larva, first instar to pre-pupal larva, prepupae to adults and the complete life cycle. Experiments were performed in temperature-controlled chambers maintained at 10, 15, 20, 25 and 30°C with a photoperiod of 11 : 13 h of light : darkness and 50–60% RH. To calculate the minimum threshold temperature of the parasitoid, parasitized egg capsules were kept under similar conditions. During 1998 and 1999 we studied the phenology and the day-degree (DD) accumulation of G. scutellatus and its parasitoid in plots of Eucalyptus globulus at six different sites in NW Spain. Every 2 weeks, the numbers of snout beetle adults and egg capsules were counted in each plot. The rate of parasitism was estimated by collecting 90 egg capsules from each plot on each sampling date. We recorded the temperatures in each plot to test whether differences in temperature alone could account for the phenology of this snout beetle. To complete a full life cycle from egg to adult, the weevil required a mean of 1119.83 ± 20.59 DD above a base temperature of 6.11°C. The parasitoid had a base temperature of 5.09°C and needed 318.16 DD to complete a life cycle. Our model indicated that three generations of snout beetle could develop each year, corresponding to peaks of snout beetle numbers in the field in March–April, June–July and November. In some years only one generation of G. scutellatus was recorded due probably to the effectiveness of the parasitoid. Differences in numbers of adults and egg capsule were recorded between neighbouring 'coastal plots' and between neighbouring 'inland plots'. Hence, climate alone does not appear to explain the phenology of G. scutellatus.	
3001	M-SEP-UK	Schofl UA, Morris DB, Verreet JA, 1994. The development of an integrated decision model based on disease threshold to control Septoria tritici on winter wheat. Brighton Crop Protection Conference, Pests and Diseases 2, 671-678.					A series of field trials was carried out in the UK to develop a threshold based decision system to control <i>Mycosphaerella graminicola</i>. The elements of the model are inoculum development, rainfall distribution, cultivar susceptibility and fungicide activity. Field studies showed that a disease threshold value based on incidence of infection on 2 leaf layers can provide information about the need for fungicide treatment. Precise timing is determined by the retrospective amount and distribution of rainfall and by cultivar susceptibility. Fungicide specific protectant and curative activity should also be considered.	
2161	M-CT_Damage	Schweizer H and Morse JG, 1997. Estimating the level of fruit scarring by citrus thrips from temperature conditions prior to the end of bloom. Crop Prot. 16: 8, 743-752.					In this study, we develop and validate multiple regression models to estimate the degree of fruit scarring by citrus thrips, Scirtothrips citri (Moulton), from heat and chill degree days. Regression coefficients indicate that cool weather during early March (2 March-16 March) and warm weather during bloom are associated with high levels of thrips scarring. The biological mechanisms leading to the temperature-fruit scarring relationships are unknown. An economic analysis suggests that using model predictions may increase the average financial return per hectare and reduce the number of insecticide treatments applied against citrus thrips.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
801	M-SN-I	Shah DA and Bergstrom GC, 2002. A Rainfall-Based Model for Predicting the Regional Incidence of Wheat Seed Infection by Stagonospora nodorum in New York. Phytopathology 92: 5, 511-518.					Our goal was to develop a simple model for predicting the incidence of wheat seed infection by Stagonospora nodorum across western and central New York in any given year. The distribution of the incidence of seed infection by S. nodorum across the region was well described by the beta-binomial probability distribution (parameters p and &#952). Mean monthly rainfalls in May and in June across western and central New York were used to predict p. The binary power law was used to predict &#952. The model was validated with independent data collected from New York. The predicted distribution of seed infection incidence was not statistically different from the actual distribution of the incidence of seed infection.	
2941	M-HZea_DistrM	Sharpe PJH, Schoolfield RM, Butler GDJr, 1981. Distribution model of Heliothis zea (Lepidoptera: Noctuidae) development times. Can. Entomol. 113: 9, 845-856.					Two geographical biotypes (G and A) of Heliothis zea Boddie were identified in a constant temperature laboratory study. The G (Georgia) biotype was found to have a mean development rate 5± 1% faster and coefficient of variability 44±9% higher than the comparable A (Arizona) biotype. Each geographical biotype was described by a biophysically based, nonlinear development function with an R2 equal to 0.995. At temperature ranging from 15.6° to 35.6°C, the adult emergence distributions transformed to a physiological age scale were shown statistically to be independent of temperature. They could be described by a "same shape" distribution function. The empirical same shape distribution for rate was not significantly different from a hypothetical normal distribution	
1381	WDCA	Shtienberg D, Dinoor A, Marani A, 1990. Wheat disease control advisory, a decision support system for management of foliar diseases of wheat in Israel. Can. J. Plant Pathol. 12, 195-203.	Dinoor A, Novauer Y, Sarid P, 1978. Optimization of chemical control of leaf rust. Hassadeh 59, 1993-1999.	Shtienberg D and Dinoor A, 1983. Optimization of chemical control of septoria tritici blotch in wheat. Hassadeh 64, 190-195.	Dinoor A, 1986. Optimization of the control of wheat leaf diseases by integretion of advisory and research work. pp. 122-127 in J Palti and Ausher R eds., Advisory work in crop pest and disease management. Springer Verlang, New York.		Wheat disease control advisory (WDCA), a computerized decision support system for managing septoria tritici blotch, leaf rust, and yellow rust, was development and field tested under the semi-arid conditions of Israel. The systems operates, on a personal computer and thus can be managed independently at any time by the user. During the decision making procedure, the system considers economics, phytopathological and both recorded and forecast weather. It analyzes the effects of these factors on the benefits of disease control and provides are recommendation for action to suppress these diseases efficiently. WDCA was tested over 4 years in 81 field experiments by its developers and by commercial growers. In plots managed according to WDCA, a significant increase of 0.78 t/ha in yield, or $92.70 per ha in net profit, was obtained relative to the common management policy. The knowledge base used for consulting WDCA, its decision making process, the technology transfer techniques, the validation procedures and their results are presented and discussed.	
1441	EPIPRE	Smeets E, Hendrickx G,Geypens M. 1994. EPIPRE, an up to date link between research and today's farming practice. Mededelingen - Faculteit Landbouwkundige en Toegepaste Biologische Wetenschappen, Universiteit Gent 59: 3b, 1233-1239.	Rabbinge R and Rijsdijk FH, 1983. EPIPRE: a disease and pest management system for winter wheat, taking account of micrometeorological factors. Bulletin OEPP 13: 2, 297-305.	Reinink K, 1986. Experimental verification and development of EPIPRE, a supervised disease and pest management system for wheat. Neth. J. Plant Path. 92: 1, 3-14.	Smeets E, Vandendriessche H, Hendrickx G, Wijngaert K de, Geypens M. 1992. Phytosanitary balance of winter wheat in 1992 by the EPIPRE advice system. Parasitica 48: 4, 139-148.			from CAB: A description is given of EPIPRE (EPIdemic PREdiction and PREvention), a computer-based advisory system for pest and disease management in spring and winter wheat in the Netherlands and Belgium. Advice is given on the necessity of treating the following pests and diseases: eyespot (Pseudocercosporella herpotrichoides), powdery mildew (Erysiphe graminis), yellow rust (Puccinia striiformis), brown rust (P. recondita), septoria leaf spot (Mycosphaerella graminicola), glume blotch (Leptosphaeria nodorum) and aphids (Sitobion avenae, Metopolophium dirhodum and Rhopalosiphum padi). A description is given of the field observations required and their use in epidemic forecasting according to an exponential pest/disease development model. Integration of the epidemic over time enables the expected damage at the end of the season to be expressed as a fraction of the expected yield, in turn enabling chemical control measures to be recommended only when the benefit of control exceeds its cost. An illustration is given of results obtained from the implementation of the model, which has been in use since 1982.
1421	M-WKB-SRE	Smiley RW, 1997. Risk assessment for Karnal bunt occurrence in the Pacific Northwest. Plant Dis. 81, 689-692.	Mavi HS, Jhorar OP, Sharma I, Gurmeet Singh, Mahi GS, Mathauda SS, Aujla SS, 1992. Forecasting Karnal bunt disease of wheat - a meteorological method. Cereal Res. Commun. 20(1-2): 67-74.	Singh D, Singh R, Rao VUM, Karwasra SS, Beniwal MS, 1996. Relation between weather parameters and Karnal bunt (Neovossia indica) in wheat (Triticum aestivum). Indian J. Agric. Sci. 66: 9, 522-525.	Stansbury CD, McKirdy SJ, 2002. Forecasting climate suitability for Karnal bunt of wheat: a comparison of two meteorological methods. Australas. Plant Pathol. 31: 1, 81-92.		Tilletia indica, the causal agent of Karnal bunt of wheat, was first detected and reported in the United States in 1996. Karnal bunt occurred in the southwestern United States as early as 1992. Wheat contaminated with teliospores of T. indica is likely to have been transported from the Southwest to other regions, including the Pacific Northwest, before presence of the pathogen was discovered. Teliospore and sporidial germination and infection are highly dependent on climatic conditions. The potential for T. indica to infect wheat in the Pacific Northwest has not been reported. The objective of this study was to use published information on environmental factors favorable for infection and historical climate data for the Pacific Northwest to analyze the environmental risk for Karnal bunt to occur if wheat fields in the Pacific Northwest become contaminated by T. indica. Conditions during the past four decades appeared favorable for infection in nonirrigated wheat during 1 of every 3 years at two (Corvallis, OR, and Spokane, WA) of 13 Idaho, Oregon, and Washington locations examined, and every year at all locations where wheat is irrigated. If introduced to the area, it appears possible for T. indica to become established in selected regions of the Pacific Northwest.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2122	M-WCFF_EmergMod	Song YooHan, Coop LB, Omeg M, Riedl H, 2003. Development of a phenology model for predicting western cherry fruit fly, Rhagoletis indifferens Curran (Diptera: Tephritidae), emergence in the Mid Columbia area of the Western United States. Journal of Asia_Pacific Entomology 6: 2, 187-192.					The western cherry fruit fly (CFF), Rhagoletis indifferens Curran, is a major pest of cherries. Because of a 'zero tolerance' for damage, detecting CFF emergence is critical for successful control. To improve predictions of CFF emergence, historical observations on first emergence, rainfall, and temperature were analyzed. The amount of precipitation in March found to accelerate the first CFF emergence. In average, CFF emerges 9 days earlier in The Dalles than in Hood River, however, the heat unit (degree days, DD) were required 71DD more in The Dalles then in Hood River. A CFF phenology model was developed based on the time varying distributed delay concepts. The model can simulate the whole phenology system including post-diapause pupal development, adult emergence, egg-laying, and larval development in user friendly menu driven system. The model also has the capability to simulate the effect of control measures on the CFF population. The model predicts field population when compared to the trap catch records last few years, however, some essential biological information was needed for inclusion in this model to make it more biologically meaningful and reliable. From the simulation, a simple heat requirement values (DD) for the first emergence were estimated as 480DD in The Dalles and 550DD in Hood River for the site-specific prediction	
2241	M-WCFF_PostDDev	Stark SB and AliNiazee MT, 1982. Model of postdiapause development in the western cherry fruit fly. Environ. Entomol. 11: 2, 471-474.					Postdiapause developmental rates of the western cherry fruit fly, Rhagoletis indifferens Curran, were determined for various constant-temperature treatments and used in the construction of a simulation model. The temperature-dependent postdiapause developmental rate relationship was modeled by fitting an exponential curve to developmental rates at low to intermediate temperatures and a quadratic curve to developmental rates at higher temperatures. This developmental rate function was incorporated into the model which predicts the postdiapause development of soil-dwelling pupae of R. indifferens as influenced by soil temperatures. From these predictions, the times of the first, 10 and 25% emergence levels, and the mean time of emergence, are predicted for the entire soil column from which emergence occurs. The model was found to be highly accurate for predicting the times of these levels of adult fly emergence.	
2323	M-BW_ThermDeath	Sterling W, Dean A, Hartstack A, Witz J, 1990. Partitioning boll weevil (Coleoptera: Curculionidae) mortality associated with high temperature: desiccation or thermal death? Environ. Entomol. 19: 5, 1457-1462.					Mortality of boll weevil, Anthonomus grandis Boheman, larvae and pupae resulting from exposure to high temperatures can be partitioned into two categories, "desiccation" and thermal death. Larvae and pupae that die from thermal death turn a greybrown color after death, do not move when probed or squeezed, and lose the resiliency of their integument. Those dying from "desiccation" will show the same characteristics but do not turn the grey-brown color; they generally retain the same color as live insects but have a very dried-out appearance. Thermal death is a function of exposure time and high temperatures. Low levels of thermal mortality appear in ~3 h at 54.4°C. An estimated 99% mortality should result from a 2-h 18-min exposure at 600C. Because soil surface temperatures sometimes reach 600C, high temperatures may be an important cause of mortality in some locations. A model for forecasting time and temperature thresholds for thermal mortality is presented.	
1781	HELSIM-I	Stinner RE, Rabb RL, Bradley JR, 1974. Population dynamics of Heliothis zea (Boddie) and H. virescens (F.) in North Carolina: a simulation model. Environ. Entomol. 3: 1, 163-168.					A model is described for stimulation of the population dynamics of Heliothis spp. The salient features of. the model include: (1) developmental means and variances about these means nonlinearly dependent on temperature; (2) separation of the general adult pool through adult attraction to spatially and temporally variant host-plant characteristics; and (3) cannabalism as a function of larval density, age-class structure within larvae, available feeding sites, and larval spatial distribution. Results of an initial simulation effort are also presented.	A model is described for simulation of the population dynamics of Heliothis zea (Boddie) and (with modifications) of H. virescens (F.). Its salient features include developmental means and variances about these means nonlinearly dependent on temperature, separation of the general adult pool through adult attraction to spatially and temporally variant food-plant characteristics, and cannibalism as a function of larval density, age-class structure within the larval population, available feeding sites, and larval spatial distribution. The results of an initial simulation effort for H. zea on maize in Johnston County, North Carolina in 1970 are presented.

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2282	M-BW_Texas	Stone ND, Rummel DR, Carroll S, Makela ME, Frisbie RE, 1990. Simulation of boll weevil (Coleoptera; Curculionidae) spring emergence and overwintering survival in the Texas Rolling Plains. Environ. Entomol. 19: 1, 91-98.					A degree-day model of boll weevil, Anthonomus grandis Boheman, spring emergence and survivorship in the Rolling Plains of Texas was developed and validated based on seven years of data that describe emergence rates of cohorts of boll weevils caged in the overwintering habitat of sand shinnery oak. The spring emergence profile was well described by a degree-day model in which the 50 and 80% points of emergence varied according to two indices of winter severity: a modified interaction term of rainfall and degree-days, and the negative degree-days accumulated during the longest run of days with temperatures below 3.9°C. These factors also were used to predict boll weevil overwintering survival, suggesting that the two processes are linked. A conceptual model of this linkage is presented.	
2485	M-BBM_Emerg	Teixeira LAF and Polavarapu S, 2001. Postdiapause development and prediction of emergence of female blueberry maggot (Diptera: Tephritidae). Environ. Entomol. 30: 5, 925-931.					Predictive models were developed to forecast the emergence of female blueberry maggot flies in highbush blueberries. Time to emergence at 20°C for pupal samples transferred from outdoors late February through mid-March, in 1997 and 1998, was very similar, suggesting both diapause completion and minimal postdiapause development at this time. Linear and nonlinear models were fitted to postdiapause development rates at several constant temperatures (7, 11, 15, 20,25, and 30°C). The low temperature development threshold for the linear model was estimated at 4.7°C, and the heat accumulation required for median emergence was 934.3 degree-days. Rate summation was initiated on 1 March, over 3 yr, and model predictions were validated with field emergence data. The linear model predicted emergence with an average error of <4 d of observed field emergence, for percentiles at and below the median, over a 3-yr period, compared with 4.0-5.4 d for the nonlinear biophysical model. The results of this study indicate that a simple linear model, driven by soil temperatures, can assist the monitoring of blueberry maggot fly in integrated pest management programs.	
181	BYDV PREDICTOR	Thackray DJ, Diggle AJ, Jones RAC, 2009. BYDV PREDICTOR: a simulation model to predict aphid arrival, epidemics of Barley yellow dwarf virus and yield losses in wheat crops in a Mediterranean-type environment. Plant Pathol. 58, 186-202.					BYDV PREDICTOR, a simulation model, was developed to forecast aphid outbreaks and Barley yellow dwarf virus (BYDV) epidemics in wheat crops in the grainbelt region of southwest Australia, which has a Mediterranean-type climate. The model used daily rainfall and mean temperature to predict aphid (Rhopalosiphum padi) buildup in each locality before the commencement of the cereal-growing season in late autumn, and to forecast the timing of aphid immigration into crops. The introduction of BYDV by aphid immigrants, aphid buildup within the crop, spread of BYDV, and yield losses were predicted for different sowing dates. The model simulations were validated with 10 years' field data from five different sites in the grainbelt, representing a wide range of scenarios. When first aphid arrival dates ranging from 1 June to 2 September were compared with predictions, 65% of the variation between sites and years was explained. Progress curves for the predicted percentage of plants infected with the serotype BYDV-PAV closely resembled the starting point and shape of those recorded in 14 out of 18 scenarios. Sensitivity analysis confirmed that the combination of a high proportion of immigrants vectoring BYDV, early sowing of crops and early start to aphid arrival relative to sowing date led to the most BYDV spread and greatest yield loss. The model was incorporated into a decision support system used by farmers in targeting sprays against aphids to prevent virus spread in autumn and winter. BYDV PREDICTOR could serve as a template for modelling similar virus/aphid vector pathosystems in other regions of the world, especially those with Mediterranean-type climates.	
2381	M-MFF_ThermDeath	Thomas DB and Mangan RL, 1997. Modeling thermal death in the Mexican fruit fly (Diptera: Tephritidae). J. Econ. Entomol. 90: 2, 527-534.					A large set of mortality data for the Mexican fruit fly, Anastrepha ludens (Loew), from induced thermal stress was fit to 4 mathematical models that are used to estimate thermal death points for quarantine level security. Two of the models, the probit and kinetic formulas, estimated death point intercepts in close agreement at the tail ends of survivorship curves. Based on the criteria of chi-square values, coefficients of determination, and confidence limits, the kinetic model had the best fit to the data. The complementary log-log model produced disparately lower death point intercepts with wider confidence limits compared with the other 3 models with the same data set.	

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1101	M-DDMFF	Thomas DB, 1997. Degree-day accumulations and seasonal duration of the pre-imaginal stages of the Mexican fruit fly (Diptera: Tephritidae). Fla. Entomol. 80: 1, 71-79.					Degree-day accumulations and puparial duration of the Mexican fruit fly, Anastrepha ludens (Loew), in the field was found to fit closely with a degree-day accumulation model developed by Leyva-Vazquez (1988) with laboratory data. Larval development time was more variable, however, and did not agree well with the laboratory based degree-day model. This may have been caused by a tendency of the larvae to remain in the fruit beyond the necessary development time and for subsequent egression to be spread over a period of weeks. Duration of the pre-imaginal stages is strongly a function of season. The puparial stage may be prolonged up to three months in the winter or be as brief as three weeks in the summer. There was no evidence of a winter diapause.	
1682	M-WSB_Hdev	Thomson AJ, Harris JWE, Silversides RH, Shepherd RF, 1983. Effects of elevation on the rate of development of western spruce budworm (Lepidoptera: Tortricidae) in British Columbia. Can. Entomol. 115: 9, 1181-1187.					A simple empirical model of temperature variation with elevation was successfully used to explain variation in observed rates of development of larvae and pupae of the western spruce budworm in mountainous terrain. Hopkins' Bioclimatic Law did not adequately describe development of stages earlier than the sixth instar. Regional differences in the effect of elevation are demonstrated and related to coastal and interior conditions. Direct solar heating effects appear to be of major significance in the early instars. The empirically-derived rates of temperature decrease could be generally applied to regions with dry inland conditions, but not to moist coastal regions.	A simple empirical model of temperature variation with altitude was used to explain variation in observed rates of development of larvae and pupae of the forest pest Choristoneura occidentalis Freeman in mountainous terrain in British Columbia in 1977. A.D. Hopkins' (1920) Bioclimatic Law did not adequately describe the development of stages before the 6th instar. Regional differences in the effect of altitude were demonstrated and related to coastal and interior conditions. Direct solar heating effects appeared to be of major importance in the early instars. The empirically derived rates of temperature decrease could be generally applied to regions with dry inland conditions but not to moist coastal regions.
1681	M-CTB	Thomson JL and Copes WE, 2009. Modelling disease progression of Camelia twig blight using a recurrent event model. Phytopathology 99, 378-384.					To improve control of camellia twig blight (CTB) using sanitation methods, a more complete epidemiologic understanding of this disease is necessary. Three CTB disease stages were modeled using recurrent event analysis. Wound inoculated stems were observed at regular intervals for appearance of disease symptoms. Survival times (time from inoculation until symptom appearance) for the three disease stages (mild, moderate, and severe) were regressed against stem diameter, monthly mean hours/day within a specified temperature range (15 to 30°C), and season (spring, summer, fall, and winter). For all three CTB disease stages, stem diameter had a protective effect on survival times, while monthly mean hours/day in the specified temperature range and warmer seasons were risk factors. Based upon median ratios, the mild disease stage developed 2 to 3 times faster in spring, summer, and fall than in winter. Similarly, moderate and severe disease stages developed 2 to 2.5 times faster. For all three disease stages, seasonal differences in stage development were smaller among fall, spring, and summer, varying from 1 to 1.6 times faster. Recurrent event modeling of CTB progression provides knowledge concerning evelopmental expression of this disease, information necessary for creating a comprehensive, integrated disease management program.	
2201	SIMBA-NEM	Tixier P, Risedeb JM, Dorel M, Malezieuxc E, 2006. Modelling population dynamics of banana plant-parasitic nematodes: A contribution to the design of sustainable cropping systems. Ecol. Model. 198, 321–331.	Tixier P, Salmon F, Chabrier C, Queneherve P, 2008. Modelling pest dynamics of new crop cultivars: the FB920 banana with the Helicotylenchus multicinctus-Radopholus similis nematode complex in Martinique. Crop Prot. 27: 11, 1427-1431.				This article describes the biological background, themodel-building methodology and some applications of SIMBA-NEM, a new model to simulate the population dynamics of two major plant-parasitic nematode species of banana, Radopholus similis and Pratylenchus coffeae. For each species, each generation is represented by one cohort. Cohorts of the same species form a chain representing the developmental stages of nematodes. A logistic function describes population growth in relation with: (i) an environmental carrying capacity (K) that depends on available banana root biomass, (ii) an intrinsic growth rate (c) and (iii) competition between nematode species. Soil water content and the quantity of nematicides used are considered to be the main variables influencing the intrinsic population growth rate of each species. SIMBA-NEM was calibrated and validated using datasets from banana cropping systems in Guadeloupe (French West Indies). By analysing the sensitivity of the model to the main parameters and performing simulations of validation for various cropping systems (banana monoculture with or without nematicide applications use and a banana/sugarcane rotation) we were able to test the ability of the model to predict nematode population dynamics under a range of conditions. SIMBA-NEM is able to predict long-term nematode population size, while taking interspecific competition into account. It also helped to define knowledge gaps in nematology and modelling. SIMBA-NEM was used to optimise the effect of nematicide applications. SIMBA-NEM can already be a very helpful tool for designing sustainable and more environment-friendly banana	

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182	M-WBLS-I	Tubajika KM, Russin JS, Harrison SA, 1999. Analysis of bacterial leaf streak epidemics on winter wheat in Louisiana. Plant Dis. 83, 541-548.					Studies were conducted to characterize spatial and temporal progress of bacterial leaf streak disease (Xanthomonas translucens pv. translucens) on susceptible (Florida 304) and moderately resistant (Terral 101) winter wheat cultivars. Epidemics were initiated with rifampicin-resistant strain 88-14rif of X. translucens pv. translucens by establishing point sources of inoculum in plot centers. Incidence of bacterial leaf streak was assessed five times in 1995 and three times in 1996, starting from the first observation of leaf streak symptoms. Rainfall, temperature, and wind speed were significantly related to disease incidence, but relative humidity was not. The Gompertz model gave the best statistical fit for the progression of disease incidence over time. Average rates of disease progress (k) obtained from the regression of bacterial leaf streak incidence against time provided a good method of comparing the cultivars Florida 304 and Terral 101 and were consistent across locations. Bacterial leaf streak disease gradients were best described by the negative exponential model. Bacterial leaf streak incidence decreased with distance from inoculum source for both cultivars. Disease incidence on Terral 101 was near 0% at 2 m from the source, and disease incidence close to the source was consistently lower on Terral 101 than on Florida 304 at all growth stages sampled. This was not unexpected because the two cultivars differed in susceptibility. Disease incidence data were more useful than severity data in providing a good estimate of disease spread away from the source.	
2021	M-CLB-EcoSys	Tummala RL, Ruesink WG, Haynes DL, 1975. A discrete component approach to the management of the cereal leaf beetle ecosystem. Environ. Entomol. 4: 2, 175-186.					Procedures are reported to systematically develop a total system model as a function of its structure and individual component models. These methods are illustrated by obtaining the dynamic models of Oulema melanopus (L.) and its larval parasite, Tetrastichus ;ulis (Walker). The models are used to study the effect of the parasite on the pest density levels under varying conditions. The results of this analysis are discussed in the context of management of the O. melanopus ecosystem. Based on this analysis, some biological experiments in the field are recommended.	
1301	M-ForSn	Tyldesley JB and Thompson N, 1980. Forecasting Septoria nodorum on winter wheat in England and Wales. Plant Pathol. 29, 9-20.					The regional incidence of septoria {Septoria nodorum Berk,) on winter wheat, as found in the National Winter Wheat Leaf Disease Survey for 1970-75, was related to weather variables and amounts of inoculum. The relation between disease shortly before harvest and days with rain through the growing season was explored by a correlation method and it was found that the closest association was with days with 1 mm or more of rain (wet days) in the period mid-May to mid-June, When explored in detail, the relation between infection and wet days showed both non-linearity and asymmetrical scatter, A graphical technique was therefore used to develop simple forecast rules. These performed well when tested against data for 1976-78, although these years did not include a septoria epidemic. In addition to wet days, the influence of other weather variables was investigated by a multiple regression technique. Sunshine in May and June and temperatures in July were found to have a slight effect on septoria incidence, as did the previous year's infection (taken as a measure of inoculum) but the overall reduction of variance was slight. It is suggested that these additional variables, together with others not treatecl quantitatively, may best be used to decide the regional forecast in marginal cases, and to make it applicable to individual crops. Attempts to relate septoria at individual sites in northern England to wet days at nearby rainfall stations were not successful; nor did rainfall data from all these stations contribute to a better regional forecast of septoria than did a few stations chosen at random.	

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2547	M-NDIST-DENCFR	Ungerer MJ, Ayres MP, Lombardero MJ, 1999. Climate of the northern distribution limits of Dendroctonus frontalis Zimmermann (Coleoptera: Scolytidae). J. Biogeogr. 26, 1133-1145.					The southern pine beetle, Dendroctonus frontalis, is among the most important agents of ecological disturbance and economic loss in forests of the south-eastern United States. We combined physiological measurements of insect temperature responses with climatic analyses to test the role of temperature in determining the northern distribution limits of D. frontalis. Laboratory measurements of lower lethal temperatures and published records of mortality in wild populations indicated that air temperatures of -16° should result in almost 100% mortality of D. frontalis. The distribution limits for D. frontalis approximate the isoline corresponding to an annual probability of 0.90 of reaching £-16 °C. Thus, D. frontalis have been found about as far north as they could possibly occur given winter temperature regimes. At latitudes from 39° N (southern Ohio) to 33° N (central Alabama), winter temperatures must exert high mortality on D. frontalis populations in at least one year out of ten. In contrast, we reject the hypotheses that summer temperatures or the distribution of host trees constrain the northern distribution of D. frontalis. Because of the short generation time of D. frontalis, its high dispersal abilities, and the cosmopolitan distribution of suitable host trees, changes in either the mean or variance of minimum annual temperatures could have almost immediate effects on regional patterns of beetle infestations. We estimate that an increase of 3 °C in minimum annual temperature could extend the northern distribution limits by 170 km. Increases or decreases in the variance of minimum annual temperatures would further relax climatic constraints on the northern distribution limits of D. frontalis. Results emphasize the ecological importance of spatial and temporal variability in minimum annual temperatures. The physiologically based models provide a tool for guiding land management decisions in forests and illustrate a general approach for pred	The southern pine beetle, Dendroctonus frontalis, is among the most important agents of ecological disturbance and economic loss in forests of the south-eastern United States. Physiological measurements of insect temperature responses were combined with climatic analyses to test the role of temperature in determining the northern distribution limits of D. frontalis. Laboratory measurements of lower lethal temperatures and published records of mortality in wild populations indicated that air temperatures of -16 degrees C should result in almost 100% mortality of D. frontalis. The distribution limits for D. frontalis approximate the isoline corresponding to an annual probability of 0.90 of reaching <=-16 degrees C. Thus, D. frontalis have been found about as far north as they could possibly occur given winter temperature regimes. At latitudes from 39 degrees N (southern Ohio) to 33 degrees N (central Alabama), winter temperatures must exert high mortality on D. frontalis populations in at least one year out of ten. In contrast, the hypotheses that summer temperatures or the distribution of host trees constrain the northern distribution of D. frontalis are rejected. Because of the short generation time of D. frontalis, its high dispersal abilities, and the cosmopolitan distribution of suitable host trees, changes in either the mean or variance of minimum annual temperatures could have almost immediate effects on regional patterns of beetle infestations. It is estimated that an increase of 3 degrees C in minimum annual temperature could extend the northern distribution limits by 170 km. Increases or decreases in the variance of minimum annual temperatures would further relax climatic constraints on the northern distribution limits of D. frontalis. Results emphasize the ecological importance of spatial and temporal variability in minimum annual temperatures. The physiologically based models provide a tool for guiding land management decisions in forests and illustrate a
2661	M-IPSXCA_Emerg	Wagner TL, Flamm RO, Coulson RN, 1986. A temperature-dependent model of reemergence of Ips calligraphus (Coleoptera: Scolytidae). Can. Entomol. 118: 9, 901-911.					Reemergence of Ips calligraphus (Germar) was studied at nine constant temperatures from 10 to 37.5°C. The relationship of adult residence time to temperature formed a backward "J"-shaped curve. Median residence times ranged from 6.25 days at 30°C to 163.5 days at 10°C. The distributions of residence times changed with temperature and were nearly uniform at the low temperatures, peaked and skewed to the right at the intermediate temperatures, and nearly symmetric at the high temperatures. Greater than 93% of all adults reemerged at temperatures from 12.5 to 35°C but only 56% reemerged at 37.5°C. Female residence time was about 26% longer than the male. A mathematical function of reemergence rates versus constant temperatures and a distribution function of normalized reemergence times predicted percentage reemergence of a population through time. In simulations, a multiple-cohort procedure was applied using frequency distributions of field attacks to identify the starting times of the model. Model predictions compared favorably with reemergence from three trees in each of four field plots.	
2641	M-IPSXCA_Dev	Wagner TL, Flamm RO, Wu HI, Fargo WS, Coulson RN, 1987. Temperature-dependent model of life cycle development of Ips calligraphus (Coleoptera: Scolytidae) Environ. Entomol. 16: 2, 497-502.					Constant temperatures from 12.5 to 37.5"C influenced duration of the withintree life cycle (egg to adult emergence) of Ips calligraphus (Germar). The relationship of median development time and constant temperature formed a backwards J-shaped curve. On the average, developing I. calligraphus spent as little as 18 d in the host at 35"C and as much as 224 d in the host at 12.5"C. Frequency distributions of development times changed with temperature and were nearly uniform at 15"C, more symmetric at 2Q-300c, and somewhat skewed to the right at 32 and 35"C. The model of Sharpe & DeMichele (1977, J. Theor. Biol. 64: 649-670) described development rates (reciprocal of median times) as a function of temperature (R2 = 0.999), and a cumulative Weibull function (Wagner et al. [1984b, Ann. Entomoi. Soc. Am. 77: 475-487]) described a single, temperature-independent distribution of normalized development times (R2 = 0.997). Combined, these functions predicted cumulative proportions of cohort emergence through time. Models were validated using a multiple-cohort simulation procedure (Wagner et ai. [1985b, Ann. Entomoi. Soc. Am. 78: 691-704]) as well as data on I. calligraphus emergence from three trees in each of three field plots. The validation suggested the model's suitability in a	

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2281	M-SPB_Long	Wagner TL, Gagne JA, Sharpe PJH, Coulson RN, 1984. Effects of constant temperature on longevity of adult southern pine beetles (Coleoptera: Scolytidae). Environ. Entomol. 13: 4, 1125-1130.					We studied the periods of time that newly emerged southern pine beetles, Dendroctonus frontalis Zimmermann, lived without food at 10 constant temperatures between 10 and 41°C. Two hundred or more adults were tested at each temperature to obtain mean longevities and longevity distributions. At 10 and 12.5°C, average longevity was about 18 days. Above 12.5OC, these times decreased exponentially to about 1 day at 41°C. Females lived longer than males held at the same temperature. There was considerable variability in average longevity for replicate experiments; the causes for this variability are discussed. Longevity distributions changed from near uniform at the lower temperatures to peaked at the higher temperatures. The data were described mathematically using a two-component model. First, an exponential function described adult dying rates (inverse of mean longevities) as a function of temperature. Second, an empirical distribution function described the cumulative percentage of beetles dying over physiological time. It is noteworthy that on a physiological time scale, one temperature-independent distribution described the data reasonably well. The combined rate and distribution functions adequately predicted the percentage of mortality of a cohort over calendar time.	
1621	M-GOSH_Herb	Wang Y, Gutierrez AP, Oster G, Daxl R, 1977. A population model for plant growth and development: coupling cotton-herbivore interaction. Can. Entomol. 109: 10, 1359-1374.					A general population model for cotton growth and development is presented. The model captures the essential properties of the biological processes, and is sufficiently flexible to the incorporation of complex physiological and behavioral characteristics. The model has been used successfully to simulate the growth and development of Acala 5J-II cotton in California. The mathematical framework for coupling plants and herbivores has been presented, and the biological implications of their damage to the plant examined in a very general way.	A general population model for the growth and development of cotton that has been used successfully to simulate the growth and development of Acala SJ-II cotton in California is presented. The mathematical framework for coupling plants and herbivores is presented, with special reference to Anthonomus grandis Boh., and the biological implications of their damage to the plant are discussed
121	M-WKB-PA	Workneh F, Allen TW, Nash GH, Narasimhan B, Srinivasan R, Rush C M, 2008. Rainfall and temperature distinguish between Karnal bunt positive and negative years in wheat fields in Texas. Phytopathology 98: 1, 95-100.					Karnal bunt of wheat, caused by the fungus Tilletia indica, is an internationally regulated disease. Since its first detection in central Texas in 1997, regions in which the disease was detected have been under strict federal quarantine regulations resulting in significant economic losses. A study was conducted to determine the effect of weather factors on incidence of the disease since its first detection in Texas. Weather variables (temperature and rainfall amount and frequency) were collected and used as predictors in discriminant analysis for classifying buntpositive and -negative fields using incidence data for 1997 and 2000 to 2003 in San Saba County. Rainfall amount and frequency were obtained from radar (Doppler radar) measurements. The three weather variables correctly classified 100% of the cases into bunt-positive or -negative fields during the specific period overlapping the stage of wheat susceptibility (boot to soft dough) in the region. A linear discriminant function model then was developed for use in classification of new weather variables into the bunt occurrence groups (+ or –). The model was evaluated using weather data for 2004 to 2006 for San Saba area (central Texas), and data for 2001 and 2002 for Olney area (north-central Texas). The model correctly predicted bunt occurrence in all cases except for the year 2004. The model was also evaluated for site-specific prediction of the disease using radar rainfall data and in most cases provided similar results as the regional level evaluation. The humid thermal index (HTI) model (widely used for assessing risk of Karnal bunt) agreed with our model in all cases in the regional level evaluation, including the year 2004 for the San Saba area, except for the Olney area where it incorrectly predicted weather conditions in 2001 as unfavorable. The current model has a potential to be used in a spray advisory program in regulated wheat fields.	
2181	M-BYDV-CN	Xiang J and Feng C, 1994. Forecast of wheat yellow dwarf disease. Acta Phytophylacica Sinisa 21: 1, 73-77.					Based on investigation data of 16 years from 1973-1988, through correlation measurement of 13 factors, the main factors in the epidemic of wheat yellow dwarf were determined, i.e. precipitation, average temperature, winter extreme minimum temperature, wintering aphid population and incidence on plants, aphid population and incidence on plants in early spring. Through multiple regression analysis and discriminant analysis, 4 forecast equations were established and verified to be effective. A standardized method for investigation of wheat yellow dwarf was also presented through analysis.	

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2861	M-IPM-PowMil	Yang Jiashu, Cao Yuanyin, Yao Ping, Zhang Shushen, Mao Guojie, 1999. Establishing IPM sistems of wheat powdery mildew in Liaohe River Basin. Acta Phytophylacica Sinisa 26: 3, 239-242.					Through more than 10 years of studies on IPM system of wheat powdery mildew, the initial fungus source and regular rule of infection cycle of wheat powdery mildew in northeast spring wheatlands were found out, the forecast equation for forecasting the occurrence and epidemic of wheat powdery mildew which accuracy was as high as 86% was established, and the population composition and virulence frequency of physiological race of wheat powdery mildew fungus in northeast spring wheatlands were also identified. Wheat powdery mildew resistant cultivars were screened out, and powdery mildew resistant cultivars applicable to Liaohe River Basin were also incubated and extended. IPM system was established by assembly and integration of IPM techniques, demonstrated over large area and gained significant social, economic and ecological benefits.	
2541	M-OFF_Demog	Yang PJ, Carey JR, Dowell RV, 1994. Temperature influences on the development and demography of Bactrocera dorsalis (Diptera: Tephritidae) in China. Environ. Entomol. 23: 4, 971-974.					The effects of seven constant temperatures (ranging from 19 to 36°C) on development, longevity, and fecundity of the oriental fruit fly, Bactrocera dorsalis (Hendel), were investigated in the laboratory. Development of preadults ranged from 30.4 d at 19°C to 17.4 d at 36°C. Egg to adult survival ranged from a high of 50% at 25°C to a low of 28% at 36°C. Adult life spans averaged 155 d at 19°C to 30 d at 36°C. The expectation of life at age 0 of adult females and males did not differ significantly. Females laid the most eggs (1,581 eggs) at 22°C and the fewest (nine eggs) at 36°C. Intrinsic rate of increase ranged from 0.095 at 34°C to 0.005 (individual per female per day) at 36°C. The population had the ability to double with the shortest time at 34°C (7.3 d) to the longest time at 36°C (130.7 d). These data can be used to maximize the production of B. dorsalis from mass-rearing facilities and to develop computer simulation models to predict B. dorsalis development and population dynamics for sterile insect release and male annihilation programs.	
2821	M-NNs	Yang XB and Batchelor WD, 1997. Modeling plant disease dynamics using neural networks. AI Applications 11: 3, 47-55.					The dynamics of 3 disease systems were analysed using neural networks. Three-layer feed forward neural networks were developed for prediction of appressorium formation of rice blast fungus (Pyricularia oryzae [Magnaporthe grisea]), seasonal progress of soyabean rust (Phakopsora pachyrhizi) and regional annual epidemics of wheat scab (Fusarium spp.). Environmental factors were used as inputs. These data represent disease dynamics at various scales, including cell, field plot and region. A five-hidden-node neural network gave the best prediction of the rice blast pathogen appressorium formation (Rsuperscript 2=0.99) using night temperature, relative humidity and dew period as inputs. The best neural network for predicting percentage soyabean rust severity had 3 inputs (first day disease was observed and thermal time for soyabean and rust development) and 19 hidden nodes. This network was trained for data collected in 1980 and gave an Rsuperscript 2 of 0.86 for a validation data set collected during 1981. The regional epidemics of 20-year wheat scab were predicted well with a 15-hidden-node neural network that used rain days, amount of rain and cumulative sunlight during reproductive stages as inputs (Rsuperscript 2=0.98). The results demonstrate that neural networks can be a useful tool in forecasting plant disease and detecting disease patterns.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2483	M-PD-DTRYONI	Yonow T, Zalucki MP, Sutherst RW, Dominiak BC, Maywald GF, Maelzer DA, Kriticos DJ, 2004. Modelling the population dynamics of the Queensland fruit fly, Bactrocera (Dacus) tryoni: a cohort-based approach incorporating the effects of weather. Ecol. Model. 173: 1, 9-30.					Queensland fruit fly, Bactrocera (Dacus) tryoni (QFF) is arguably the most costly horticultural insect pest in Australia. Despite this, no model is available to describe its population dynamics and aid in its management. This paper describes a cohort-based model of the population dynamics of the Queensland fruit fly. The model is primarily driven by weather variables, and so can be used at any location where appropriate meteorological data are available. In the model, the life cycle is divided into a number of discreet stages to allow physiological processes to be defined as accurately as possible. Eggs develop and hatch into larvae, which develop into pupae, which emerge as either teneral females or males. Both females and males can enter reproductive and over-wintering life stages, and there is a trapped male life stage to allow model predictions to be compared with trap catch data. All development rates are temperature-dependent. Daily mortality rates are temperature-dependent, but may also be influenced by moisture, density of larvae in fruit, fruit suitability, and age. Eggs, larvae and pupae all have constant "establishment" mortalities, causing a defined proportion of individuals to die upon entering that life stage. Transfer from one immature stage to the next is based on physiological age. In the adult life stages, transfer between stages may require additional and/or alternative functions. Maximum fecundity is 1 400 eggs per female per day, and maximum daily oviposition rate is 80 eggs/female per day. The actual number of eggs laid by a female on any given day is restricted by temperature, density of larva in fruit, suitability of fruit for oviposition, and female activity. Activity of reproductive females and males, which affects reproduction and trapping, decreases with rainfall. Trapping of reproductive males is determined by activity, temperature and the proportion of males in the active population. Limitations of the model are discussed.	
2502	M-NEURONET	Zhang WenJun and Zhang XiYan, 2008. Neural network modeling of survival dynamics of holometabolous insects: a case study. Ecol. Model. 211: 3/4, 433-443.					Survival process and mortality distribution of holometabolous insects were hard to be described by mechanistic models due to their distinctive development stages in the life cycle. Neural networks are flexible approximators for linear or nonlinear ecological systems. This study aimed to evaluate the effectiveness and performance of BP ANN (feed-forward backpropagation artificial neural network) and conventional models in modeling the survival process and mortality distribution of a holometabolous insect, Spodoptera litura F. (Lepidoptera: Noctuidae). Training data on survival process and mortality distribution of S. litura were recorded under different temperatures. BP ANN, three empirical models, five probabilistic density functions, a multi-stage based dynamic model, and a trend surface model were used to modeling the time changing and temperature dependent relationships of the insect. Overall performances were compared among these models. The results demonstrated that BP ANN could be effectively used to model the survival process and mortality distribution of S. litura. It exhibited the best performance in the onedimensional and two-dimensional simulations. Some features in survival process of the holometabolous insect, like the static stages for egg and pupa, were better simulated by BP ANN.	
2221	M-scab-fuzzy	Zhou Chonghe, 1990. Principal component in epidemic factors of wheat scab and a forecast model. Acta Phytophylacica Sinisa 17: 4, 917-921.					Five significant correlative factors were chosen from the nineteen factors of toreperiod weather, the fungus sources and 17 years' data of wheat scab. After analysis of principal components, four major factors were selected. By means of fuzzy comprehensive judgement, a forecast model was established as follows: Y =(0.2857 0.2619 0.2381 0.2143)• R In backtesting past 17 years' data with submodel III, all results coincided with the facts. Practical forecast in 1987 was correct and in 1988 was satisfactory.	
1261	M-WBPS	Zinkernagel V, Tischner H, Hausladen H, Habermeyer H, 2002. Practical application of integrated disease management. Plant Prot. Sci. 38:Special Issue 1, 212-220					A decision support system for cereal diseases and late blight of potatoes has been developed at the Chair of Phytopathology, Technische Universität München. The Wheat and Barley Prognosis System has been in use for many years by the Bavarian official advisory service. It is based on an exact diagnosis and established biological thresholds influenced by weather. Certain fungicides are recommended also covering diseases which have not reached the threshold. Diseases under consideration are eye spot disease, powdery mildew, Septoria leaf blotch, Septoria leaf and glume blotch, tan spot, brown and yellow rusts.The PhytophthoraModel Weihenstephan consists of two parts, weather based prognosis and monitoring in the unsprayed control plots. Spraying recommendations are given based on the results of the above-mentioned parts and considering cultivar behaviour and blight development in the field. The first spraying in the season as well as the timing of the following ones are crucial. This model does not give any recommendations regarding which active ingredient should applied. However there is a distinction made with regard to contact (protective) fungicides and systemic fungicides. The PhytophthoraModel Weihenstephan has been in use for several years in Germany as well as in Austria.	

Id	Acronym	Main Reference	Related reference 2	Related reference 3	Related reference 4	Related reference 5	Abstract From Paper	Additional abstract
2881	M-ForecastMod-CN	Zou Yuhu, Zheng Lianzhi, Zhang Yunhua, Liu Tiruo, Peng Chi, Zhang Yunquan, Shi Cuiping, Xu Qunzhou and Pan Chunyan, 1995. Forecast method for the epidemic of spring wheat scab in Heilongjiang Province. Acta Phytophylacica Sinisa 22: 4, 297-302.					This paper statistically analyzed the relationship between field scab data accumulated for 23 yeas since 1959 in the disease nursery set up in Heilongjiang 8-5-4 Farm and various meteorological factors by means of correlation analysis, multiple regression and stepwise regression, etc. The statistical analysis illustrated that the change of local wheat scab epidemic strength was mainly determined by 3 meteorological factors, i.e. average relative humidity, rain days and sunshine duration in wheat heading to flowering period. Based on these main factors, the epidemic forecast model for wheat scab was set up. The results of back test and fisting test indicated that this model reflected the epidemic rule of local wheat scab relatively correctly and could be used for the forecast of scab epidemic strength.	

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Models for pest's epidemiology: review, documentation, and evaluation for Pest Risk Analysis (Mopest)

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Mopest web-portal

User's Manual

v. 1.0

Table of Contents

Introduction

The main objective of the Mopest project is to carry out a review and to produce an exhaustive inventory of the models describing the establishment, development, and/or spread of plant pests on crops in Europe. This overview focus on the models that can be potentially used for accurate and robust quantitative prediction of pest risk through the use of climate and / or plant growth (phenology) as input factors.

The inventory must be the product of a thorough review of the relevant published literature on pest risk models, including articles in peer-reviewed journals, proceedings, and other publications, as well as in reports from competent authorities/organizations. Pest models available on web-sites and in computer programs must also be considered. The review must be performed following the principles of the systematic review criteria; by using explicit, systematic methods selected in order to minimize bias, the review will provide reliable findings from which conclusions can be drawn and decisions made.

The purpose of this text is to provide guidance for the use of the Mopest inventory. The Manual is organized into three chapters. Chapter 1 is devoted to the systematic literature search; instruction is given about how to search and review literature. Chapter 2 describes the use of the Mopest inventory; instructions are given to Standard Users, who consult the inventory for retrieving models about pests (paragraph 2.1), and to Power Users, who modify the inventory by adding new entries or editing existing entries (paragraph 2.2). Chapter 3 provides a coding manual with instructions and examples about how to fill in all the fields of the inventory. Examples related to the systematic literature search and to a complete record of the inventory are provided in the annexes.

Chapter 1 – Systematic literature search

The Power Users, who are allowed to extend the inventory with new entries, must perform a literature review according to the principles of the systematic review; in doing so, they must follow a defined strategy, as illustrated in paragraph 1.1. Moreover, the models retrieved by means of the literature search must meet certain eligibility criteria (paragraph 1.2) to be included in the inventory.

1.1 Literature search strategy

In a structured search, the search strategy is based on four successive components: What, Where, Words, and the Working method (Zins, 1999).

The **What** component refers to the phrasing of the search. Phrasing the search is aimed at focusing the search by specifying the needed information. The process of phrasing requires the searcher to define the needed knowledge (or in most cases the needed information) in terms of distinct search assignments (Zins, 1999).

> In Mopest, phrasing comes directly from the inventory's scope: searches must focus on models that simulate the pest in terms of presence/absence, prevalence, incidence, and severity, and as a function of weather variables or variables of the host plant (growth and /or development).

The **Where** component refers to the determination of where to search.. The search assignment prescribes the potential resources. Locating potential resources is usually easy for experienced searchers who are familiar with the relevant subject matter. In these common cases, the search becomes a two-phase assignment. First, the searcher must locate relevant resources, using structured search techniques. Then he/she can proceed to execute the primary assignment properly (Zins, 1999).

> For the Mopest inventory, information can be searched in any literature database, e.g., in CAB Abstract (http://www.cabdirect.org), Agris (http://www.fao.org/agris/search/search.do), and in the World Wide Web.

The **Words** component refers to the selection of search-words. The search-words affect the precision of the results. They should generate adequate results, i.e., they should not be too broad or too narrow. Selecting suitable words requires some basic knowledge and skills. The searcher should properly characterize the needed information, based on subject-related terminology. He/she should correctly spell the search-words, using printed or computerized desk reference sources (e.g., dictionaries, spelling checkers, glossaries, and thesauri) (Zins, 1999).

> An effective literature search for potential Mopest entries can be performed by means of a combination of multi-choice of keywords, according to the following model (the model conforms to CAB Abstract syntax):

(Latin name of the causal agent OR common English name of the pest/disease)
AND
(English name of the host plant)
AND
(model OR simulation OR prediction OR forecast)

Tips for the searcher

i) *Always follow the format and syntax rules required by the search engine of the database used. For example, follow rules for use of parenthesis, Boolean operators, and symbols like * or $ for truncation.*
ii) *When the name of a pest has recently changed because of nomenclature change or new taxonomic classification, the search should be carried out for both the most recent and the old version of the name.*
iii) *When both the teleomorph and the anamorph of a fungus participate in causing the disease under consideration, both their Latin names should be used in the search.*
iv) *When the above-mentioned keywords do not produce any results, the search can be repeated using Latin names at higher taxonomic levels.*
v) *If the pest of interest is polyphagous (i.e., if it affects several host plants) and the search aims at focusing on a single crop, then the name of the host should be added to the keywords.*

The **Working method** refers to how the information is retrieved. The working method depends on certain conditions (e.g., the features of the search tools or the resources, the nature of the assignment, the searcher's expertise, etc.). There are two basic methods of information retrieval: browsing and typing a query. Note, however, that hypertext and hypermedia formats allow two kinds of browsing connectivity: 'occasional' and structured. Occasional browsing is based on associative links, while structured browsing is usually utilized in hierarchical lists (Zins, 1999). The following working method was defined for Mopest:

1. perform the literature search in CAB Abstracts database (or any chosen database);
2. review each paper found on the basis of information in title and abstract: if the paper meets the eligibility criteria based on its title and abstract, it is considered of potential interest for Mopest; otherwise, it is discarded (note: term ‘potential’ means that a paper could eventually be included in the inventory, discarded, or used as a related reference of another entry, on the basis of the information drawn after the full text is analyzed);
3. retrieve the full papers considered of potential interest for Mopest;
4. review the full paper: if the paper meets the eligibility criteria, it is considered of interest for Mopest; otherwise it is discarded or used as a related reference of another entry;
5. select further papers from the “references” section of the papers found; these papers are managed as indicated above, starting from point 3.

1.2 Eligibility criteria for selecting items to be included in the Mopest's review

To be included into the Mopest inventory, publications must meet the following eligibility criteria:

- The papers must concern models describing the establishment, development, and/or spread of plant pests on crops in Europe; in this context, the term "pest" includes any species, strain, or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO, 2008);
- The papers must concern models that can be potentially used for accurate and robust quantitative prediction of pest risk, i.e., the models must use climate and / or plant growth (phenology) as input factors;
- The papers must be published in peer-reviewed journals, proceedings, and other publications, as well as in reports from competent authorities/organizations, or be available on web-sites and in computer programs;
- The model structure must be transparent and reproducible.

On the basis of these eligibility criteria, commercial software solutions that are not supported by peer-reviewed publication and that do not provide description of the algorithms should not be included.

Chapter 2 – Use of the Mopest inventory

The only technical requirements for accessing the Mopest web-portal are the following:

- an Internet connection;
- a personal computer with an installed web browser.

The Mopest web-portal is accessible only to authorized users. Two types of user profiles are available:

1. Standard User (see paragraph 2.1);
2. Power User (see paragraph 2.2).

The Standard User can:

- view the database content;
- search within the database (either through a basic or an advanced search feature).

The Power User can:

- view the database content;
- search within the database (either through a basic or an advanced search feature);
- perform the typical actions of a database management administrator: enter, update, and delete information about models.

If you have any doubts concerning your user profile, please contact the application administrator.

2.1 Standard User

The Standard User is allowed to:

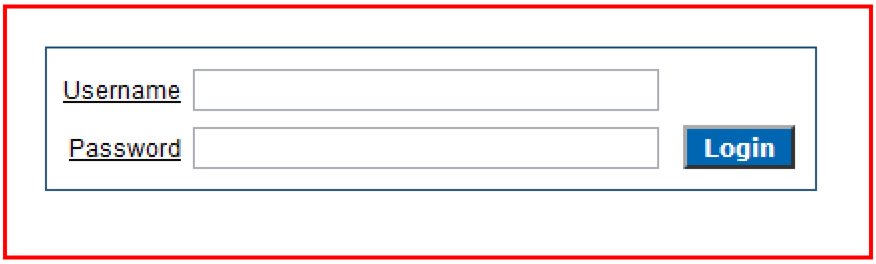
- view the database content;
- search within the database (either through a basic or an advanced search feature).

2.1.1 Login

The Mopest web portal is available at the following address:

http://193.205.43.248:8081/apex/f?p=112:13
(address to be updated when the application will be moved to the EFSA server)

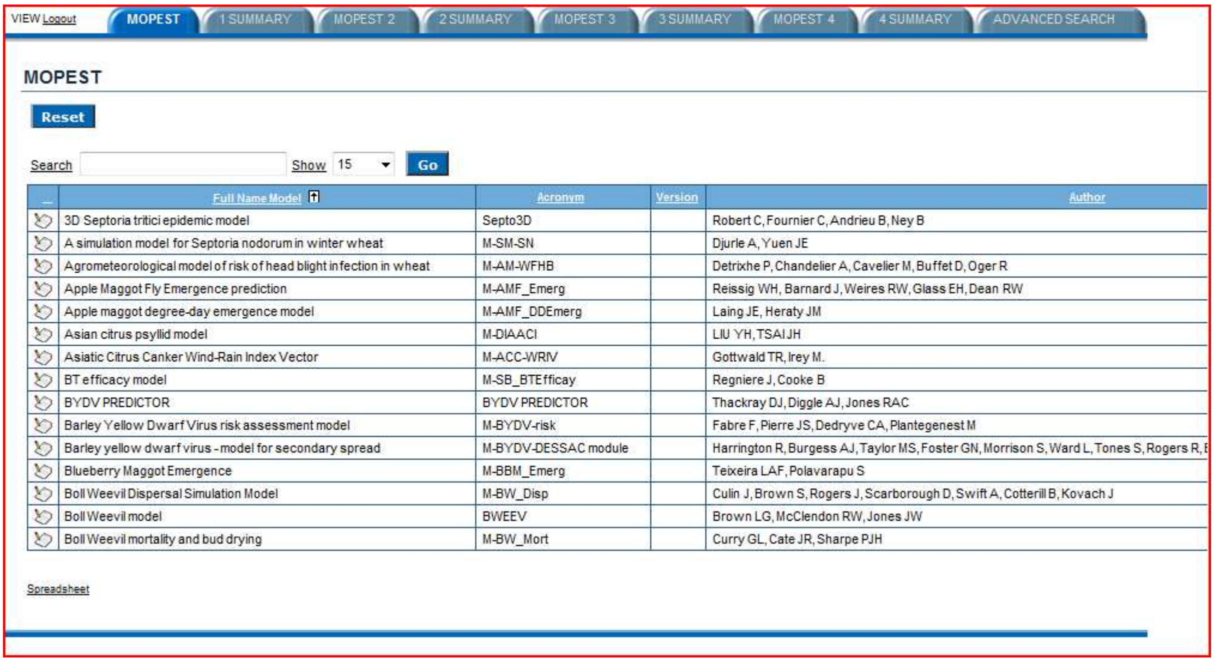
The initial page is the login page:



Enter your Username and Password and press the "Login" button.

2.1.2 Initial View

Below, a screenshot of the initial view (the so called "results page") is presented:



Full Name Model	Acronym	Version	Author
3D Septoria tritici epidemic model	Septo3D		Robert C, Fournier C, Andrieu B, Ney B
A simulation model for Septoria nodorum in winter wheat	M-SM-SN		Djurle A, Yuen JE
Agrometeorological model of risk of head blight infection in wheat	M-AM-WFHB		Detrixhe P, Chandelier A, Cavelier M, Buffet D, Oger R
Apple Maggot Fly Emergence prediction	M-AMF_Emerg		Reissig WH, Barnard J, Weires RW, Glass EH, Dean RW
Apple maggot degree-day emergence model	M-AMF_DDEmerg		Laing JE, Heraty JM
Asian citrus psyllid model	M-DIAACI		LIU YH, TSAI JH
Asiatic Citrus Canker Wind-Rain Index Vector	M-ACC-WRIV		Gottwald TR, Irey M.
BT efficacy model	M-SB_BTEfficay		Regniere J, Cooke B
BYDV PREDICTOR	BYDV PREDICTOR		Thackray DJ, Diggle AJ, Jones RAC
Barley Yellow Dwarf Virus risk assessment model	M-BYDV-risk		Fabre F, Pierre JS, Dedryve CA, Plantegenest M
Barley yellow dwarf virus - model for secondary spread	M-BYDV-DESSAC module		Harrington R, Burgess AJ, Taylor MS, Foster GN, Morrison S, Ward L, Tones S, Rogers R,
Blueberry Maggot Emergence	M-BBM_Emerg		Teixeira LAF, Polavarapu S
Boll Weevil Dispersal Simulation Model	M-BW_Disp		Culin J, Brown S, Rogers J, Scarborough D, Swift A, Cotterill B, Kovach J
Boll Weevil model	BWEEV		Brown LG, McClendon RW, Jones JW
Boll Weevil mortality and bud drying	M-BW_Mort		Curry GL, Cate JR, Sharpe PJH

As shown in the above picture, the application has been organized in different "sheets" accessible through the labels ("MOPEST", "MOPEST 2", "MOPEST 3", "MOPEST 4") on the upper-right corner of the screen. Further sheets concern the summary pages and the advanced search.

From this page you are allowed to perform the following actions: browse the content of the database, access the summary pages, do a basic or advanced search, or move to a different sheet.
The results page will be presented to you as the initial page after login or whenever you perform a search operation. Let us analyse this page in detail.

_	Full Name Model	Acronym	Version	Author	Id
	3D Septoria tritici epidemic model	Septo3D		Robert C, Fournier C, Andrieu B, Ney B	981
	A simulation model for Septoria nodorum in winter wheat	M-SM-SN		Djurle A, Yuen JE	1081
	Agrometeorological model of risk of head blight infection in wheat	M-AM-WFHB		Detrixhe P, Chandelier A, Cavelier M, Buffet D, Oger R	1041
	Apple Maggot Fly Emergence prediction	M-AMF_Emerg		Reissig WH, Barnard J, Weires RW, Glass EH, Dean RW	2261
	Apple maggot degree-day emergence model	M-AMF_DDEmerg		Laing JE, Heraty JM	2702
	Asian citrus psyllid model	M-DIAACI		LIU YH, TSAI JH	1121
	Asiatic Citrus Canker Wind-Rain Index Vector	M-ACC-WRIV		Gottwald TR, Irey M.	2001
	BT efficacy model	M-SB_BTEfficay		Regniere J, Cooke B	2341

The results are organized in a table with field names in the column headings. By clicking on a field name, you can arrange the results either in ascending or descending order. The small arrow near the field name tells you which field you are currently using to order the results. The arrow's direction tells you if the current order is ascending or descending.

Here is how the bottom of the page appears:

	Boll Weevil Dispersal Simulation Model	M-BW_Disp		Culin J, Brown S, Rogers J, Scarborough D, Swift A, Cotterill B, Kovach J	2322
	Boll Weevil model	BWEEV		Brown LG, McClendon RW, Jones JW	2482
	Boll Weevil mortality and bud drying	M-BW_Mort		Curry GL, Cate JR, Sharpe PJH	2242

row(s) 1 - 15 of 160

Spreadsheet

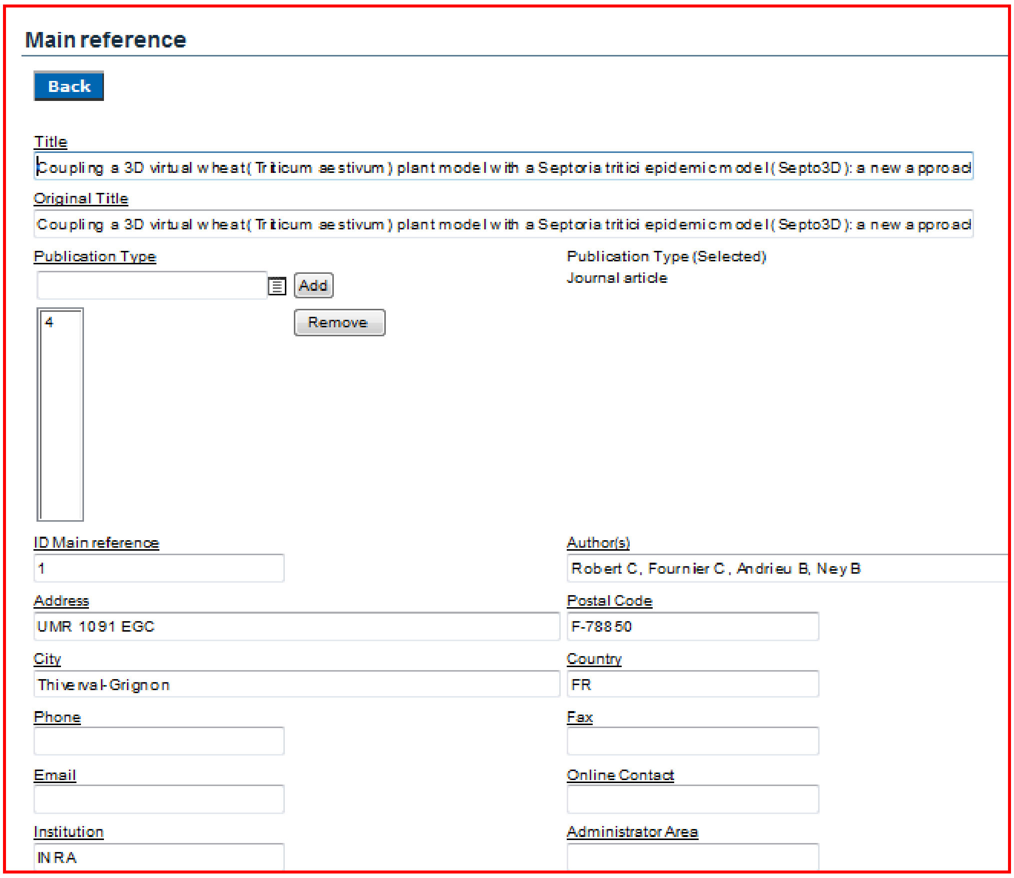
The "Spreadsheet" link allows you to download a Comma Separated Values ('csv') file containing the complete search results. Please note that:

- the 'csv' file produced will contain only the fields visible on the results table;
- by clicking the "Spreadsheet" link from the initial view page, you can download the entire database content;
- 'csv' files can be opened with the Microsoft Excel program.

On the bottom-right side of the page, a drop-down menu allows you to select the range of rows to show. Press the "Next" and "Previous" links to move among pages.

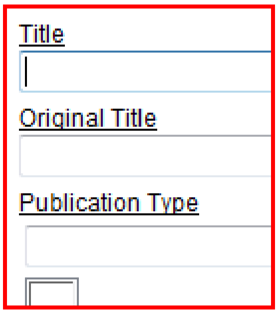
2.1.2.1 View model details

From the results page, click on the icon on the first column to access the model details page:

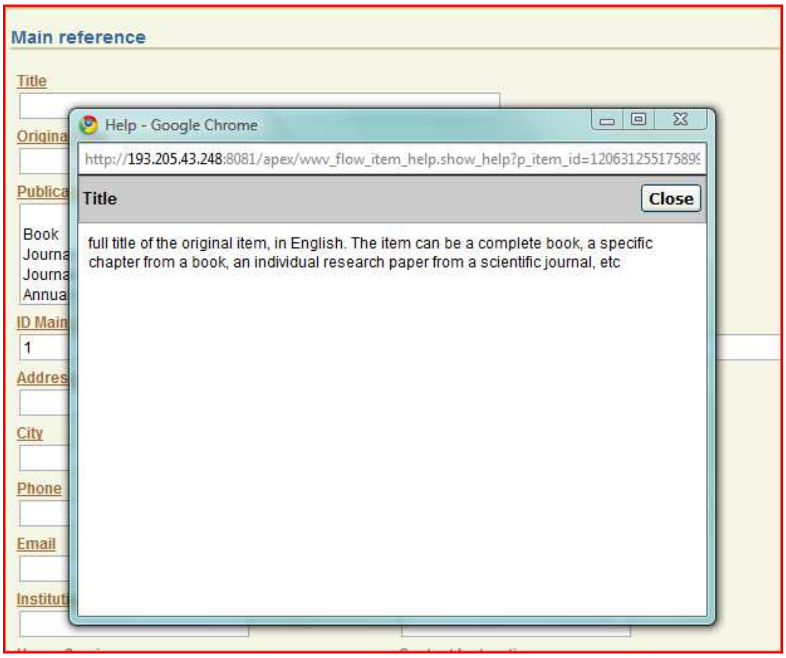


As a Standard User, you are allowed to browse among the fields and to select their content, but you cannot modify the content.

Whenever you find an underlined field name, a help text is provided.



Click on the field name to access the help text; a popup window like this will open:



The online help explains the meaning of a field and its expected content.

Press the “Back” button to go back to the previous page.

2.1.3 Printable summary page

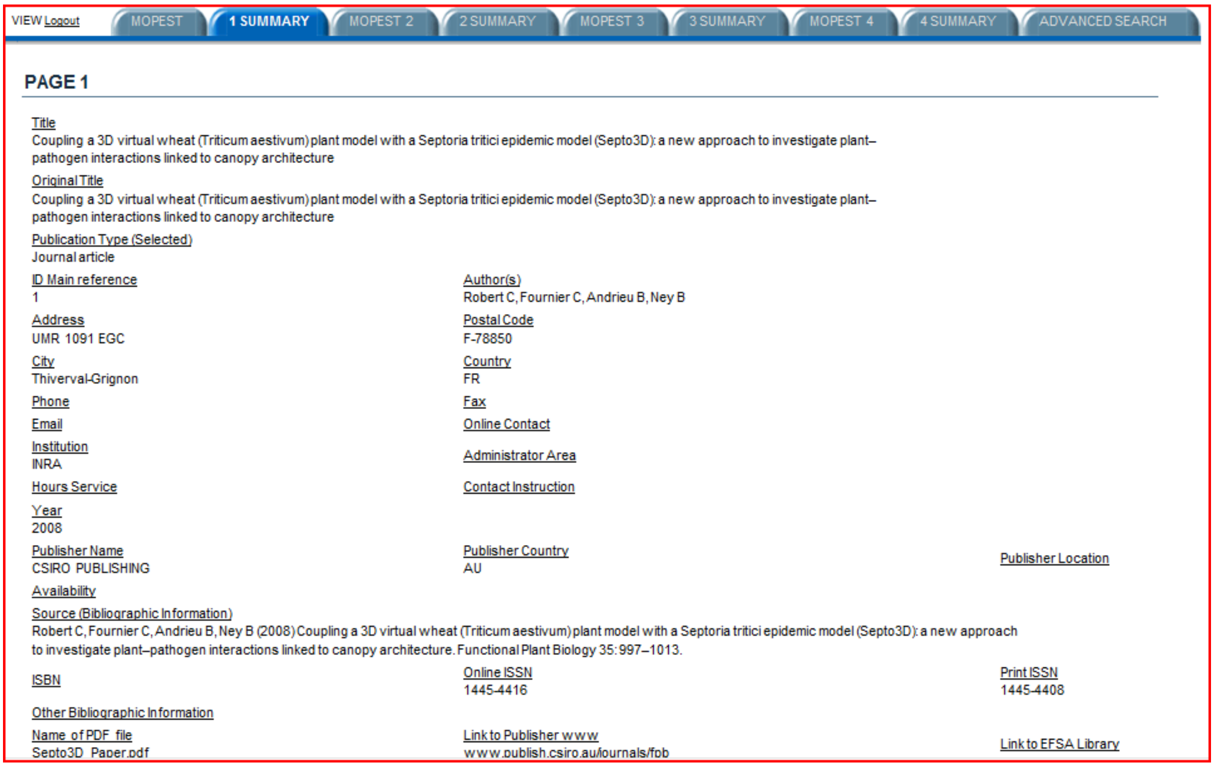
The Mopest web-portal allows you to create a summary page that can be used to print model information.
To access the summary page for the MOPEST sheet of a specific model, follow these steps:

- click on the "MOPEST" tab on the upper menu;
- from the results table, enter into the details page of the model you are interested in;
- click on the "1 SUMMARY" tab on the upper menu.

Here you have access to the summary page for the selected model. To print it, use the "Print page" feature of your browser (also accessible through the keyboard shortcut CTRL+p).

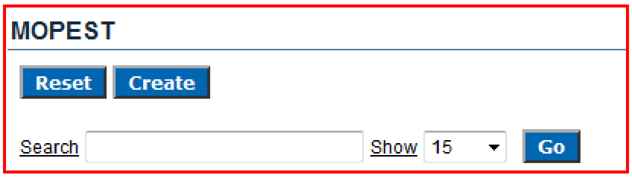
To print the complete details about a model, repeat the steps above also for the MOPEST 2 (2 SUMMARY), MOPEST 3 (3 SUMMARY), and MOPEST 4 (4 SUMMARY) sheets.

The figure below shows how a printable version of the MOPEST sheet appears:



2.1.4 Basic Search

The basic search box is located above the results table:



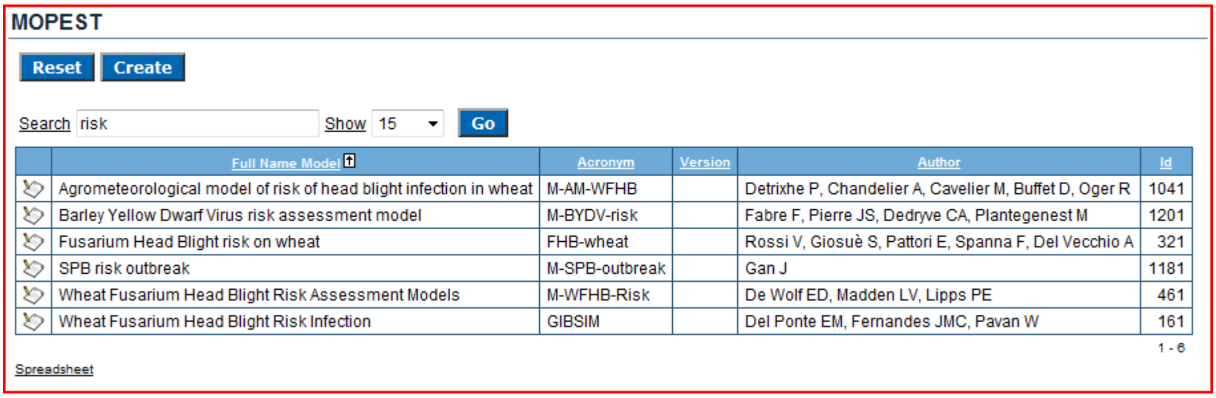
To perform a basic search, enter a string (one or a few keywords) in the "Search" text box. The string will be searched within the following fields: ID, title, keywords, and abstract. Press "Go" or the Enter key on your keyboard to start searching.

The search feature is not case sensitive. This means that when you search for "risk" you will obtain results containing both "risk" and "Risk".

You can specify the number of results to be displayed by selecting the appropriate item in the drop-down menu called "Show".

The "Reset" button clears any text typed in the textbox and allows you to do a new search. Unless you reset them, your search criteria will be stored by the system, even if you move through different sheets.

The figure below shows the results table after searching for the keyword “risk” in the “MOPEST” sheet.


MOPEST

Reset Create

Search risk Show 15 Go

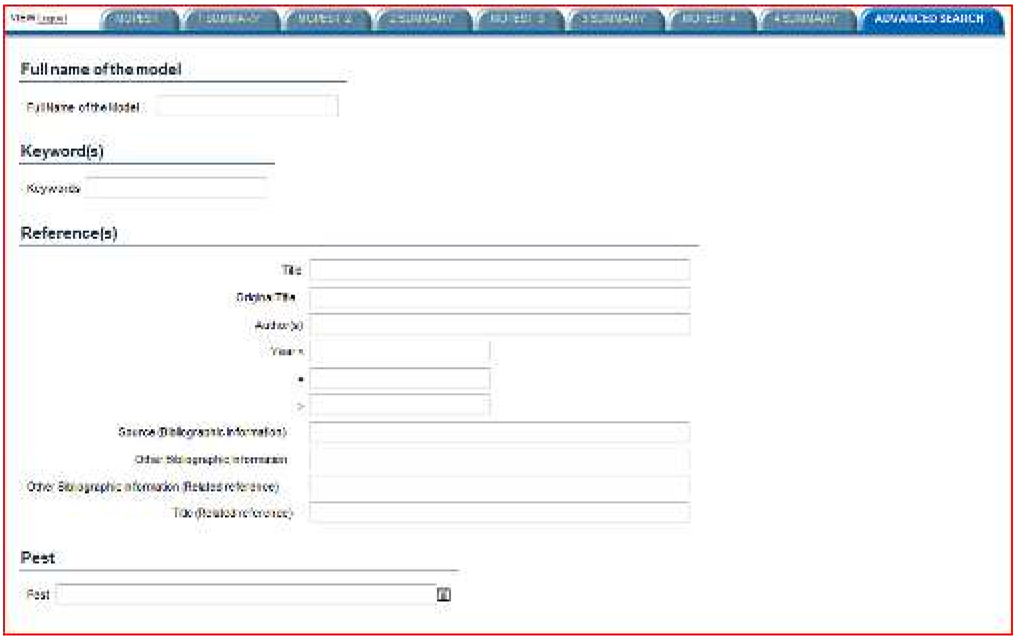
	Full Name Model	Acronym	Version	Author	Id
	Agrometeorological model of risk of head blight infection in wheat	M-AM-WFHB		Detrixhe P, Chandelier A, Cavelier M, Buffet D, Oger R	1041
	Barley Yellow Dwarf Virus risk assessment model	M-BYDV-risk		Fabre F, Pierre JS, Dedryve CA, Plantegenest M	1201
	Fusarium Head Blight risk on wheat	FHB-wheat		Rossi V, Giosuè S, Pattori E, Spanna F, Del Vecchio A	321
	SPB risk outbreak	M-SPB-outbreak		Gan J	1181
	Wheat Fusarium Head Blight Risk Assessment Models	M-WFHB-Risk		De Wolf ED, Madden LV, Lipps PE	461
	Wheat Fusarium Head Blight Risk Infection	GIBSIM		Del Ponte EM, Fernandes JMC, Pavan W	161

1 - 6

Spreadsheet

2.1.5 Advanced Search

To perform an advanced search, press the “Advanced search” label on the upper menu. The page below is displayed:



The advanced search allows you to combine several criteria for searching within the Mopest database.
Here is the list of fields for which you can specify the search criteria:

- full name of the model
- keywords/descriptors
- title
- original title
- author(s)
- year

- source (bibliographic information)
- other bibliographic information
- title (related references)
- pests (Latin and common name)
- plants (Latin and common name)
- type of model
- measured variable(s) (weather)
- measured variable(s) and parameters(s) (pests)
- measured variable(s) and parameters(s) (crops)
- pest output
- loss output
- output(s) description
- language
- validation
- model application

The search criteria are connected by the Boolean operator “AND”. This means that when you specify two search parameters, the system will find only the models satisfying both the conditions. The same happens when specifying three or more conditions.

The results of an Advanced search are presented in the same way as those of a basic search (see previous section). In the results page, press the “Reset” button to clear the search parameters and to display the complete contents of the database. Unless you reset them, your search criteria will be stored by the system, even if you move through different sheets.

2.1.6 Logout

Press the “Logout” link on the top-left corner of the screen to leave the application. As a result, the login page will appear. You can also logout by closing your browser window.

2.2 Power User

The Power User is allowed to:

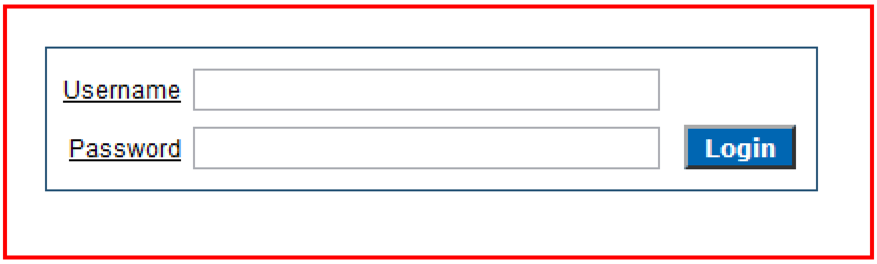
- view the database content;
- search within the database (either through a basic or an advanced search feature);
- perform the typical actions of a database management administrator: enter, update, and delete information about models.

2.2.1 Login

The Mopest web portal is available at the following address:

http://193.205.43.248:8081/apex/f?p=112:13
(address to be updated when the application will be moved to the EFSA server)

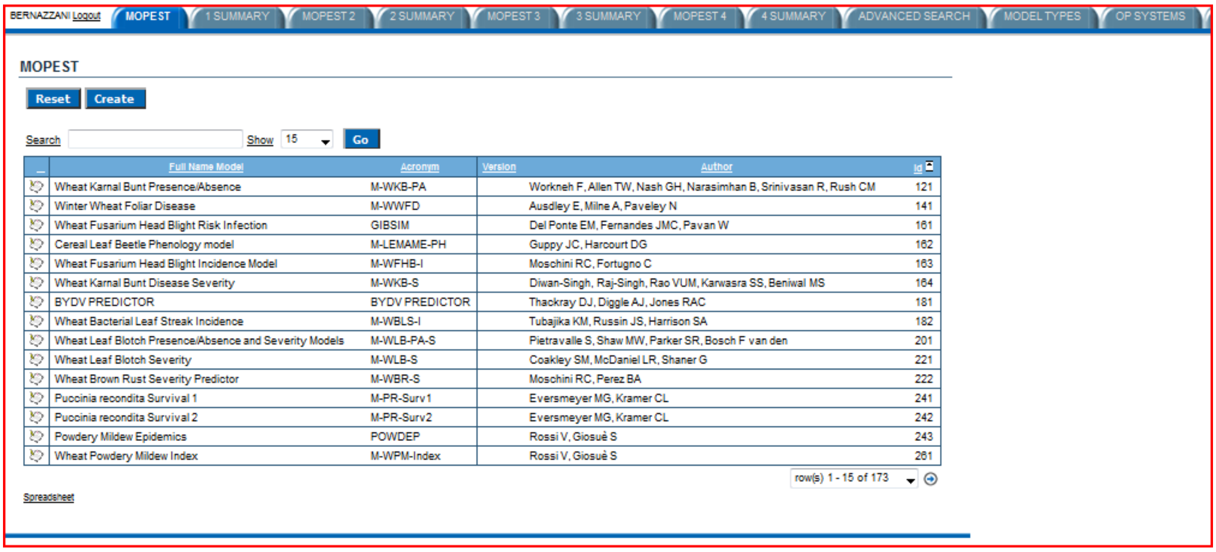
The initial page is the login page:



Enter your Username and Password and press the “Login” button.

2.2.2 Initial View

Below, a screenshot of the initial view (the so called “results page”) is presented:



Full Name Model	Acronym	Version	Author	Id
Wheat Karnal Bunt Presence/Absence	M-WKB-PA		Workneh F, Allen TW, Nash GH, Narasimhan B, Srinivasan R, Rush CM	121
Winter Wheat Foliar Disease	M-WWFD		Ausdley E, Milne A, Paveley N	141
Wheat Fusarium Head Blight Risk Infection	GIBSIM		Del Ponte EM, Fernandes JMC, Pavan W	161
Cereal Leaf Beetle Phenology model	M-LEMAME-PH		Guppy JC, Harcourt DG	162
Wheat Fusarium Head Blight Incidence Model	M-WFHB-I		Moschini RC, Fortugno C	163
Wheat Karnal Bunt Disease Severity	M-WKB-S		Diwan-Singh, Raj-Singh, Rao VUM, Karwasra SS, Beniwal MS	164
BYDV PREDICTOR	BYDV PREDICTOR		Thackray DJ, Diggle AJ, Jones RAC	181
Wheat Bacterial Leaf Streak Incidence	M-WBLS-I		Tubajika KM, Russin JS, Harrison SA	182
Wheat Leaf Blotch Presence/Absence and Severity Models	M-WLB-PA-S		Pietravalle S, Shaw MW, Parker SR, Bosch F van den	201
Wheat Leaf Blotch Severity	M-WLB-S		Coakley SM, McDaniel LR, Shaner G	221
Wheat Brown Rust Severity Predictor	M-WBR-S		Moschini RC, Perez BA	222
Puccinia recondita Survival 1	M-PR-Surv1		Eversmeyer MG, Kramer CL	241
Puccinia recondita Survival 2	M-PR-Surv2		Eversmeyer MG, Kramer CL	242
Powdery Mildew Epidemics	POWDEP		Rossi V, Giosuè S	243
Wheat Powdery Mildew Index	M-WPM-Index		Rossi V, Giosuè S	261

As shown in the above picture, the application has been organized in different "sheets" accessible through the labels on the upper-right corner of the screen.
The sheets called "MOPEST", "MOPEST 2", "MOPEST 3", and "MOPEST 4" contain the model information. Other sheets concern the summary pages and the advanced search functionality.
The sheets from "MODEL TYPES" to the end allow the Power User to manage the content of some drop-down menus. In fact, the content of some fields is expected to be extremely dynamic (e.g., operating systems, programming languages, etc.). The only way to manage these fields properly is to allow the Power Users to edit their content autonomously.
These additional sheets can be managed in the same way as sheets from MOPEST to MOPEST 4: to edit the existing entries, follow the instructions in section 2.2.2.2; to add new entries, perform the steps described in section 2.2.3.

From this page, you are allowed to perform the following actions: browse the content of the database, access the summary pages, do a basic or advanced search, or move to a different sheet.
The results page will be presented to you as the initial page after login or whenever you perform a search operation. Let us analyse this page in detail.

_	Full Name Model	Acronym	Version	Author	Id
	3D Septoria tritici epidemic model	Septo3D		Robert C, Fournier C, Andrieu B, Ney B	981
	A simulation model for Septoria nodorum in winter wheat	M-SM-SN		Djurle A, Yuen JE	1081
	Agrometeorological model of risk of head blight infection in wheat	M-AM-WFHB		Detrixhe P, Chandelier A, Cavelier M, Buffet D, Oger R	1041
	Apple Maggot Fly Emergence prediction	M-AMF_Emerg		Reissig WH, Barnard J, Weires RW, Glass EH, Dean RW	2261
	Apple maggot degree-day emergence model	M-AMF_DDEmerg		Laing JE, Heraty JM	2702
	Asian citrus psyllid model	M-DIAACI		LIU YH, TSAI JH	1121
	Asiatic Citrus Canker Wind-Rain Index Vector	M-ACC-WRIV		Gottwald TR, Irey M.	2001
	BT efficacy model	M-SB_BTEfficay		Regniere J, Cooke B	2341

The results are organized in a table with field names in the headings. By clicking on a field name, you can arrange the results in ascending or descending order. The small arrow near the field name indicates which field you are currently using to order the results. The arrow's direction indicates whether the current order is ascending or descending.

Here is how the bottom of the page appears:

	Boll Weevil Dispersal Simulation Model	M-BW_Disp		Culin J, Brown S, Rogers J, Scarborough D, Swift A, Cotterill B, Kovach J	2322
	Boll Weevil model	BWEEV		Brown LG, McClendon RW, Jones JW	2482
	Boll Weevil mortality and bud drying	M-BW_Mort		Curry GL, Cate JR, Sharpe PJH	2242

row(s) 1 - 15 of 160

Spreadsheet

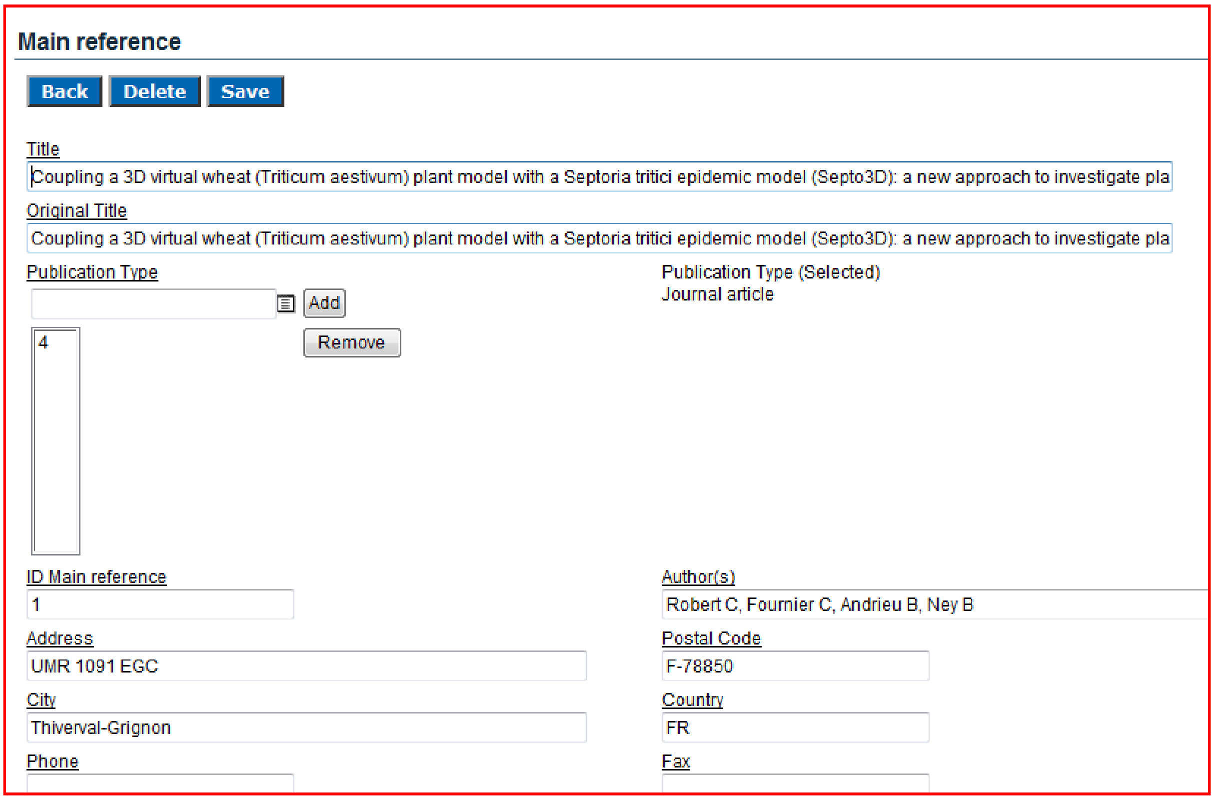
The "Spreadsheet" link allows you to download a Comma Separated Values ('csv') file containing the complete search results. Note that:

- the 'csv' file produced will contain only the fields visible on the results table;
- by clicking the "Spreadsheet" link from the initial view page, you can download the entire database content;
- 'csv' files can be opened with the Microsoft Excel program.

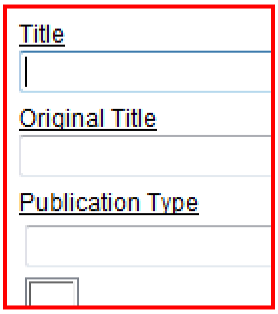
On the bottom-right side of the page, a drop-down menu allows you to select the range of rows to display. Press the "Next" and "Previous" links to move among pages.

2.2.2.1 View model details

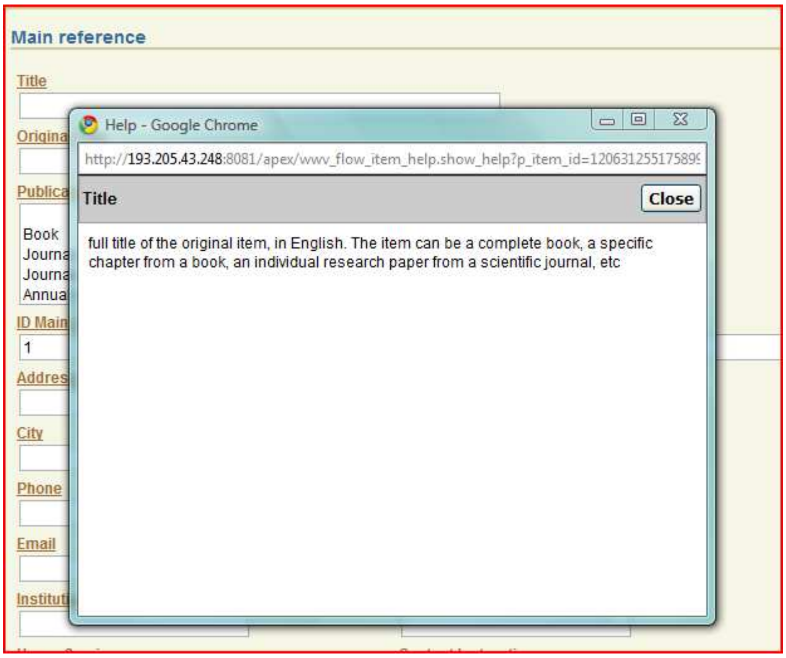
From the results page, click on the  icon on the first column to access the model details page:



Whenever you find an underlined field name, a help text is provided.



Click on the field name to access the help text; a popup window like this will open:



The online help explains the meaning of a field and its expected content.

2.2.2.2 Edit model details

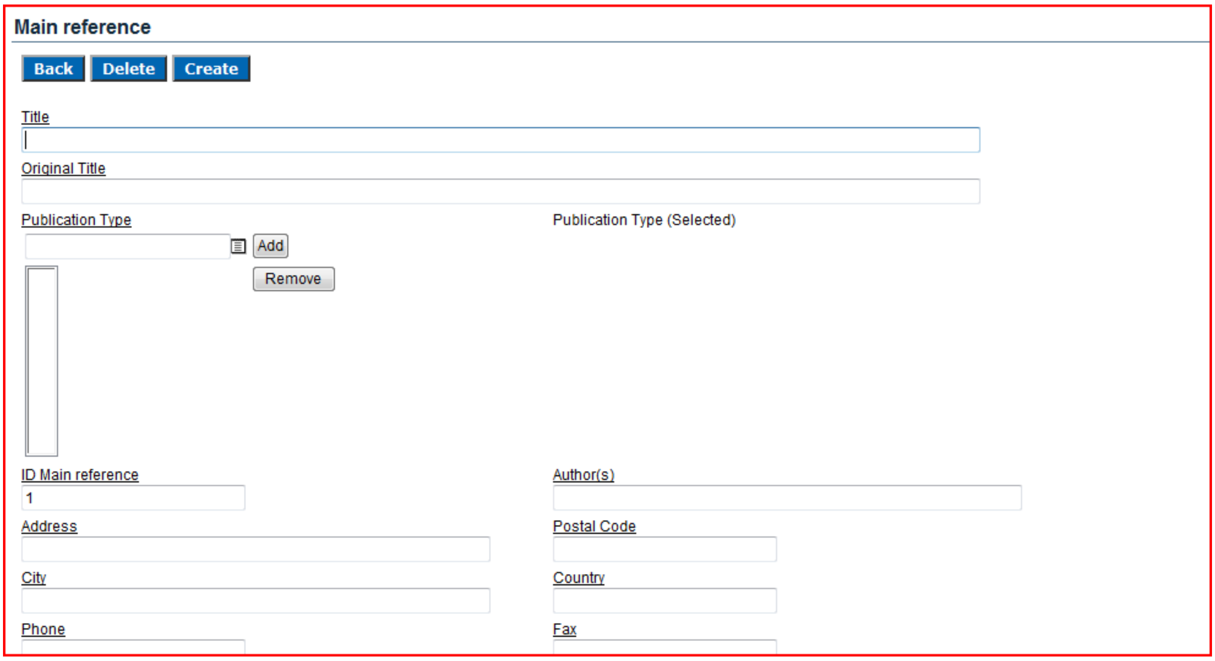
In the model details page, Power Users can edit the contents of the fields. When you have finished editing, press the “Save” button to store the new data.

Press the “Delete” button to delete the record that you are currently examining. Before this command is executed, a confirmation message is displayed.

Press the “Back” button to move back to the results page.

2.2.3 Enter a new model

From the initial view screen, press the “Create” button to add a new model to the database. The following screenshot shows a typical insert page:



After entering all the information (see next section to find out how to handle the various field types), press the “Create” button to save the record.
The compulsory fields are identified by an asterisk like this: *

Press either the “Delete” or the “Back” buttons to leave the current page without saving the entered information.

As indicated above, the information related to each model is organized in four sheets, from MOPEST to MOPEST 4. Therefore, to complete the addition of a new item into the inventory, you must perform the following actions:

- Enter the MOPEST sheet and create it by entering the available information;
- Enter the MOPEST 2 sheet; from the “Model acronym” field, choose the acronym entered in the MOPEST sheet and fill in all the other fields;
- Enter the MOPEST 3 and then the Mopest 4 sheets; choose the proper acronym and fill in the forms as you did for the MOPEST 2 sheet.

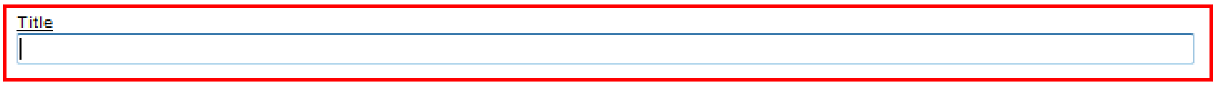
To facilitate this process, the acronym of the last entered model will always be the first entry of the “Model acronym” drop-down menu.

Detailed information on how to fill-in each field of each sheet is reported in the Coding Manual (Chapter 3).

2.2.3.1 Field types

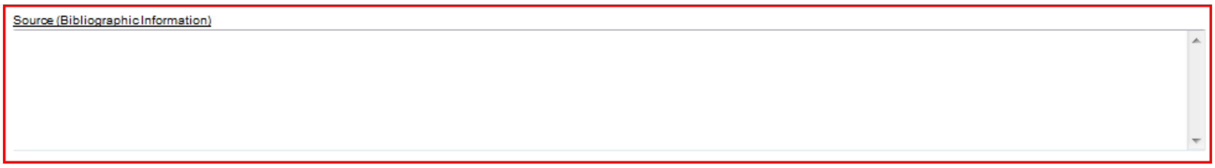
When entering new information about a model, you can find several field types that are described below.

<u>Text Box</u>



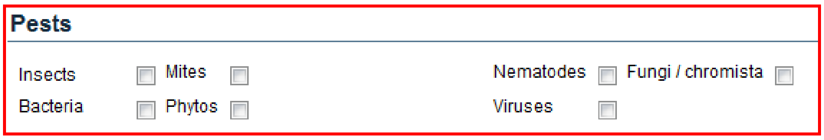
Text boxes are one-row areas that allow you to input text. You are not allowed to create new rows in text boxes.

<u>Text Area</u>



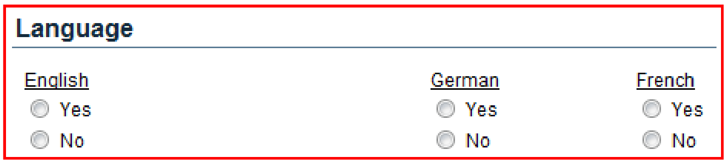
Text areas are text fields that can span several rows. This is very useful when you have to copy and paste text from an external source.

<u>Check Box</u>



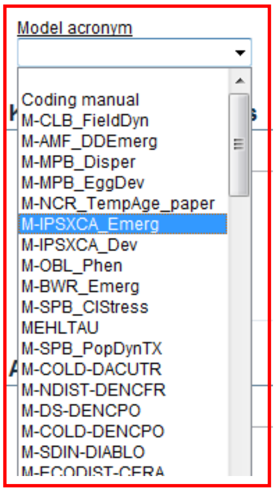
Check boxes allow you to select one or more options from a set of alternatives.

<u>Radio Button</u>



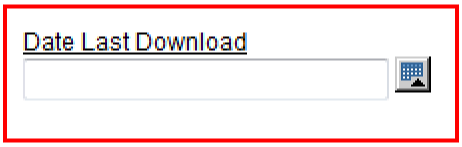
Radio buttons allow you to select one - only one - option from a set of alternatives.

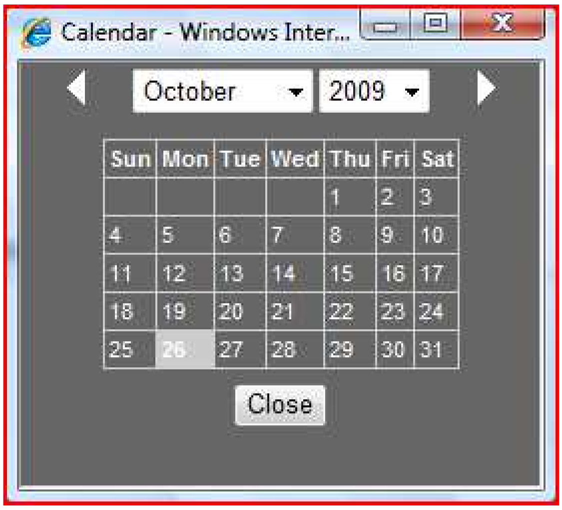
Drop-down box



Drop-down boxes allow you to select one element in a list. Click on the black arrow to open the list.

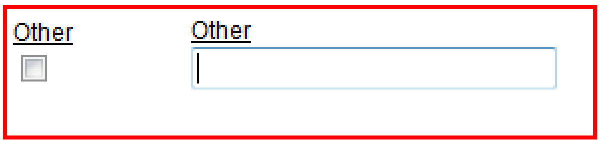
Date field





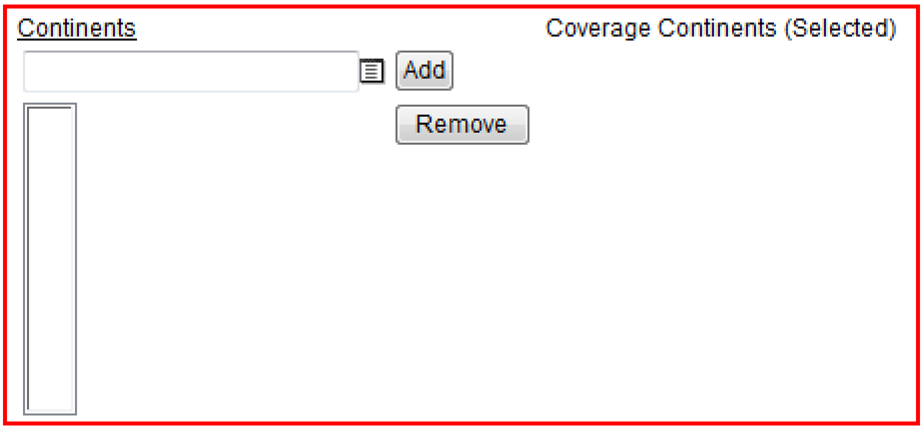
This field allows you to enter a date. Click on the icon and a popup window with the calendar will open. Select the proper month and year, and click on the day box. The corresponding date will be automatically added to the field.

“Other” field



This control allows you to specify an additional text when the existing choices do not match your case. To use this field, check the box with the "Other" label and specify the text string in the appropriate box.

Multiple Values field



Multiple Values fields allow you to pick up and add one or more elements from a wide list of choices. To add a new element, perform the following actions:

- Click on the icon; a pop-up page will open;
- On the pop-up, either browse the pages with the "Next" and "Previous" buttons, or search for a keyword;
- Within the search results click on the proper entry; the pop-up will automatically close, and the related value will be displayed in the text box;
- Press the "Add" button to include the element in the new list;
- Repeat this procedure for every element you want to add.

To remove an entry that you have accidentally added, simply select the value from the list and press the "Remove" button.
These fields are usually paired with a read-only field (called "Country Subdivisions (Selected)" in the example above), which is used to properly display the actual content of the selection.

2.2.4 Printable summary page

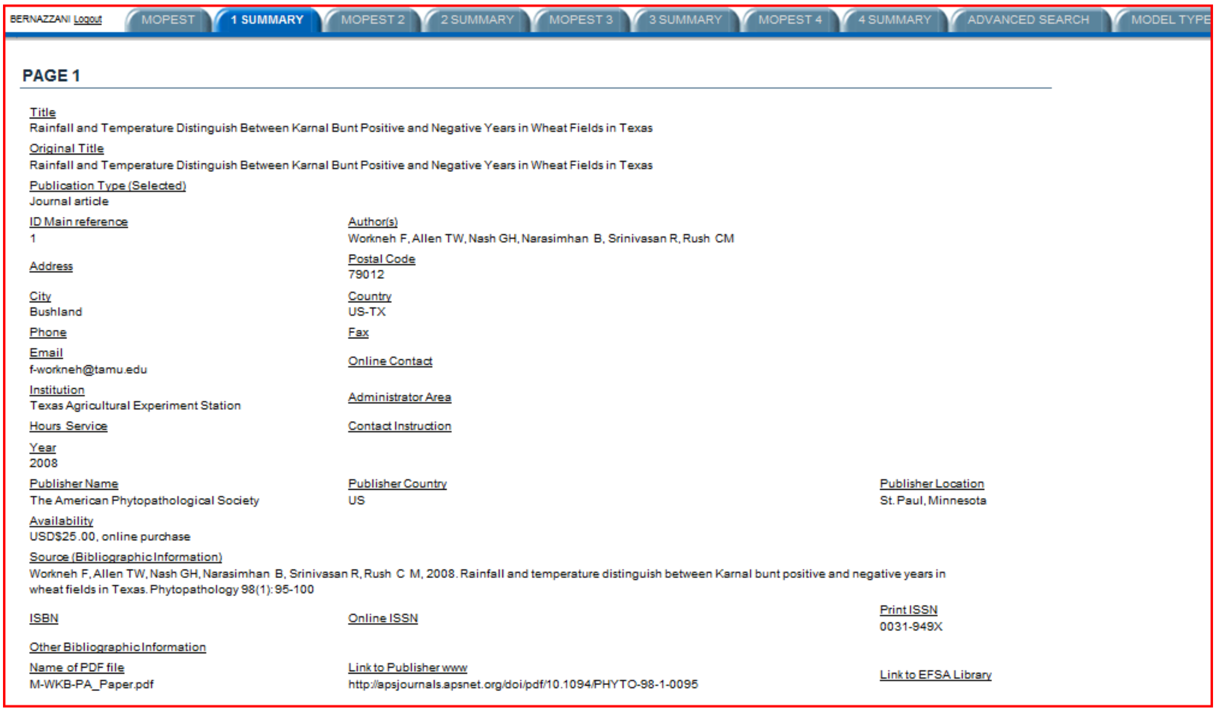
The Mopest web-portal allows you to create a summary page that can be used to print model information.
To access the summary page for the first MOPEST sheet of a specific model, follow these steps:

- click on the "MOPEST" tab on the upper menu;
- from the results table, enter the details page of a model of your choice;
- click on the "1 SUMMARY" tab on the upper menu.

Here you have access to the summary page for the selected model. To print the summary page, use the "Print page" feature of your browser (also accessible through the keyboard shortcut CTRL+p).

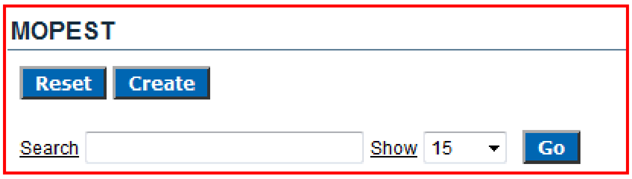
To print the full details about a model, repeat the steps above for the MOPEST 2 (2 SUMMARY), MOPEST 3 (3 SUMMARY), and MOPEST 4 (4 SUMMARY) sheets.

The figure below shows how a printable version of the MOPEST sheet appears:



2.2.5 Basic Search

The basic search box is located above the results table:



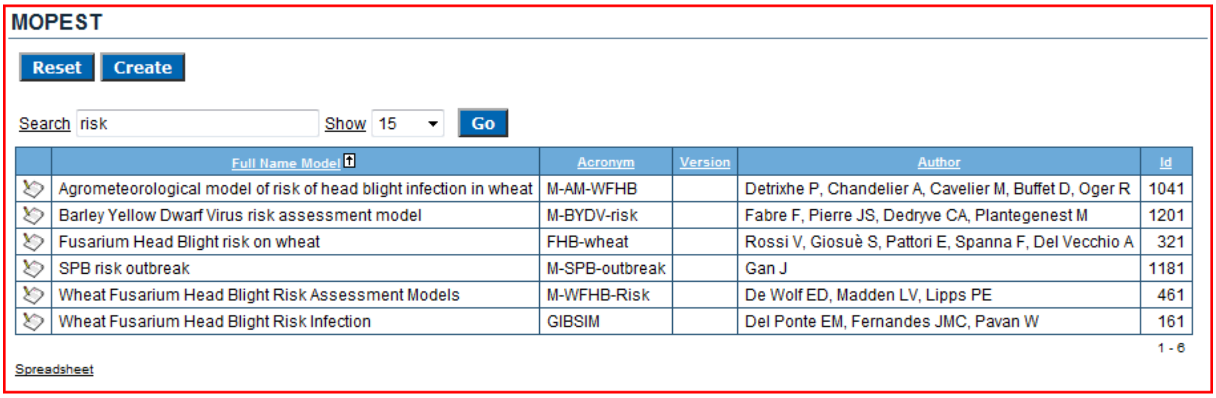
To perform a basic search, enter a string (one or a few keywords) in the “Search” text box. The string will be searched within the following fields: ID, title, keywords, and abstract. Press “Go” or the Enter key on your keyboard to start searching.

The search feature is not case sensitive. When you search for “risk”, for example, you will be presented with results containing both “risk” and “Risk”.

You can specify the number of results to be displayed by selecting the appropriate item in the drop-down menu called “Show”.

The “Reset” button clears any text typed in the textbox and allows you to do a new search. Unless you reset your search criteria, they will be stored by the system, even if you move through different sheets.

The figure below shows the results table when searching for the keyword “risk” in the “MOPEST” sheet.


MOPEST

Reset Create

Search risk Show 15 Go

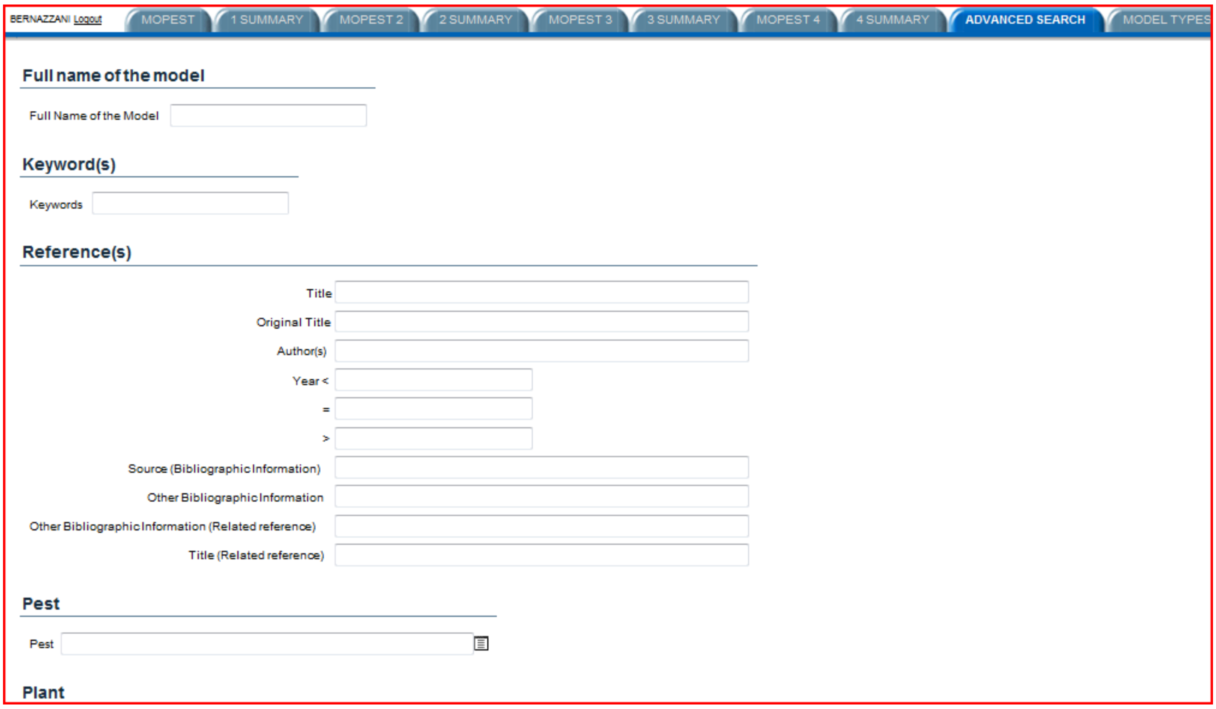
	Full Name Model	Acronym	Version	Author	Id
	Agrometeorological model of risk of head blight infection in wheat	M-AM-WFHB		Detrixhe P, Chandelier A, Cavelier M, Buffet D, Oger R	1041
	Barley Yellow Dwarf Virus risk assessment model	M-BYDV-risk		Fabre F, Pierre JS, Dedryve CA, Plantegenest M	1201
	Fusarium Head Blight risk on wheat	FHB-wheat		Rossi V, Giosuè S, Pattori E, Spanna F, Del Vecchio A	321
	SPB risk outbreak	M-SPB-outbreak		Gan J	1181
	Wheat Fusarium Head Blight Risk Assessment Models	M-WFHB-Risk		De Wolf ED, Madden LV, Lipps PE	461
	Wheat Fusarium Head Blight Risk Infection	GIBSIM		Del Ponte EM, Fernandes JMC, Pavan W	161

1 - 6

Spreadsheet

2.2.6 Advanced Search

To access the advanced search functionality, press the “Advanced search” label on the upper menu. The page below is displayed:



The advanced search allows you to combine several criteria in order to search within the Mopest database.
Here is the list of fields for which you can specify the search criteria:

- full name of the model

- keywords/descriptors
- title
- original title
- author(s)
- year
- source (bibliographic information)
- other bibliographic information
- title (related references)
- pests (Latin and common name)
- plants (Latin and common name)
- type of model
- measured variable(s) (weather)
- measured variable(s) and parameters(s) (pests)
- measured variable(s) and parameters(s) (crops)
- pest output
- loss output
- output(s) description
- language
- validation
- model application

Note that the search criteria are connected by the Boolean operator "AND". This means that when you specify two search parameters, the system will find only the models satisfying both the conditions. The same happens when specifying three or more conditions.

The results of an advanced search are presented in the same way as those for a basic search (see previous section). In the results page, press the "Reset" button to clear the search parameters and to display the entire contents of the database. Unless you reset your search criteria, they will be stored by the system, even if you move through different sheets.

2.2.7 Logout

Press the "Logout" link on the top-left corner of the screen to leave the application. As a result, the login page will appear. You can also logout by closing your browser window.

Chapter 3 – Coding Manual

The Mopest application is organized in different "sheets" accessible through identification labels. To insert a new record, four sheets must be filled in: MOPEST, MOPEST 2, MOPEST 3, and MOPEST 4. A printable version of these sheets is provided by 1 SUMMARY, 2 SUMMARY, 3 SUMMARY, and 4 SUMMARY, respectively.
When inserting a new record, you may find it necessary to extend the list of choices of a multi-choice field if a needed descriptor is not listed among the available ones. The sheets devoted to this function are the following: MODEL TYPES, OP SYSTEMS, PROG LANGS, CALC VARS WEATHER, HOST VARS, MEAS VARS WEATHER, METHOD USED, PEST VARIABLES, SENSOR LOCATIONS, PUBLICATION TYPES, PEST OUTPUT, LOSSES OUTPUTS, MEASURED PARAMETER PEST, and MEASURED PARAMETER CROP.
The four sheets to be filled in for each record, as well as the summary and additional sheets, are described in this chapter.

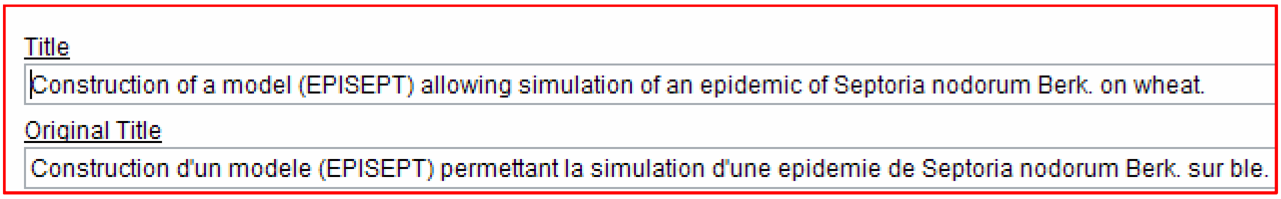
MOPEST

Main reference

The Main reference is the complete reference of the literature source. This reference, automatically labelled as #1, is the **main published paper** on the model, i.e., it is the most relevant work describing the model or the last version of the model itself.

Title: full title of the original item, in English.

Original Title: the title of the item in the original language; to be listed with Roman script only (see example below).

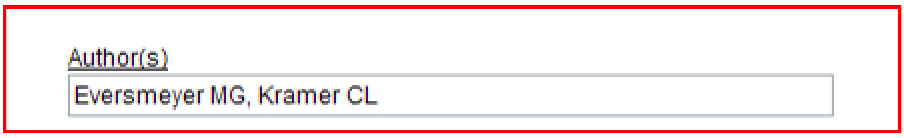


Publication Type: the description of the type of publication, the choice is made by means of a "Multi values field". Each reference is assigned to one of the following categories: Book, Journal issue, Journal article, Annual report section, Thesis, Bulletin, Correspondence, Editorial, Miscellaneous, Book chapter, Conference proceedings, Conference paper, Abstract only, Annual report, Patent, Standard, and Bulletin article. This list can be extended by assessing the sheet PUBLICATION TYPES (see the section "Additional fields", at the end of this chapter).

Once the kind of reference has been chosen and the selection has been saved, the selected category will be displayed on the right side of the sheet under "Publication Type (Selected)" (see example below). The number represents the descriptor ID, which is useful for database management.

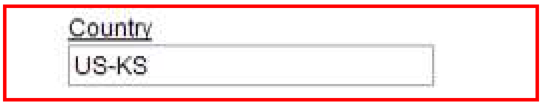
ID Main reference: the identification number automatically associated with the reference. It is a numeric value that identifies the main reference in the next sheets. **The Main reference is automatically assigned an ID value of 1.**

Author(s): list of the name(s) of all personal authors of the original item. Each name is entered as family name, initials of the name, comma delimited (see example below).



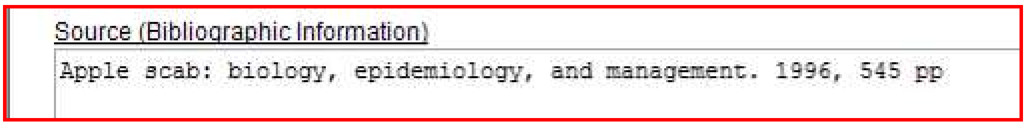
Address: the address of the organization where the work was done, not the author's present address if he or she has moved. If more than one organization was involved in the work, only the organization of the first named author will be given.

Postal Code: postal code (ZIP or other).
City: city of the location.
Country: country, according to ISO3166-2 (see example below).

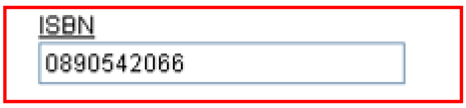


Phone: telephone number for contacting the organization or individual.
Fax: fax number for contacting the organization or individual.
Email: email address for contacting the organization or individual.
Online Contact: on-line information that can be used to contact the individual or organization.
Institution: name or official initials of organization.
Administrator Area: state or province of the location.
Hours Service: time period when the organization or individual can be contacted.
Contact Instruction: supplemental instructions on how or when to contact the organization or individual.
Year: the four-digit year in which the original document was published.
Publisher Name: name of publisher.
Publisher Country: country of publisher.
Publisher Location: location of publisher.
Availability: order numbers, price, or other information that help in the retrieval of the original document (see examples below).

Source (Bibliographic Information): source could include document title, conference title, date and location, date of publication, volume, issue, page numbers, and any other applicable bibliographic information. These titles must be entered in full (see example below).



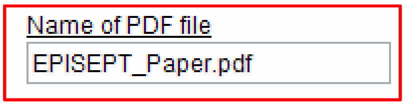
ISBN (International Standard Book Number): to be included only where applicable or available. If available, the ISBN should be copied directly from the book (the example below is for the book: MacHardy WE [1996] Apple scab: biology, epidemiology, and management. American Phytopathological Society [APS Press], St. Paul, Minnesota, USA, 545 pp).



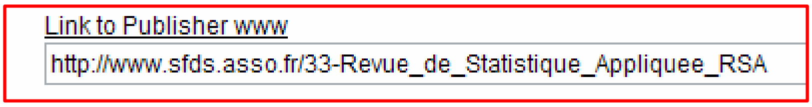
Online ISSN: International Standard Serial Number (ISSN) for online publication; to be included only where applicable or available.
Print ISSN: International Standard Serial Number (ISSN) for publication; to be included only where applicable or available.

Some journals have both the Online and Print ISSN (the example below is for the *Annals of Applied Biology*).

Other Bibliographic Information: this information could include document title, conference title, date and location, date of publication, volume, issue, page numbers, and any other applicable bibliographic information. These titles must be entered in full.
Name of PDF file: name of the electronic copy of the published paper, if available within EFSA extranet. As a convention, the paper should be called with the acronym of the model described followed by underscore "Paper" and the extension ".pdf" (see example below).



Link to Publisher www: URL of the publisher of the paper, e.g., the journal where the paper can be bought or downloaded. To access this internet address, copy and paste the URL into the internet browser (see the example below for the *Revue de Statistique Appliquee*).

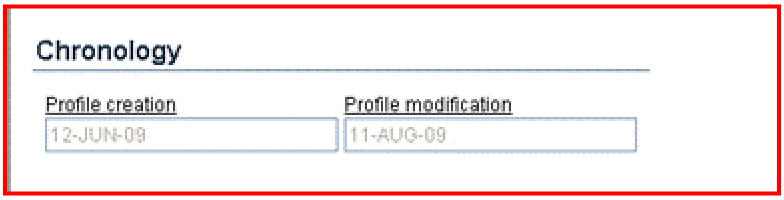


Link to EFSA Library: address of the paper in the EFSA library, if available.

Related references
Labelled as #2 to #n, the related references concern works related to the main reference. Related references include previous versions, validations, etc., made either by the original researcher or another researcher.
ID related reference #2 to #n: this is a numeric value (e.g., 2) that identifies this reference in the next sheets. This number is automatically created.
Authors #2 to #n: list of the name(s) of all personal authors of the original item. Each name is entered as the family name followed by initials and is comma delimited.
Year #2 to #n: the four-digit year in which the original document was published.
Title #2 to #n: full title of the original item, in English. The item can be a complete book, a specific chapter from a book, an individual research paper from a scientific journal, etc.
Other Bibliographic Information #2 to #n: this information could include document title, conference title, date and location, date of publication, volume, issue, page numbers, and any other applicable bibliographic information. These titles must be entered in full.
Name of PDF file #2 to #n: name of the electronic copy of the published paper, if available within EFSA extranet.
Link to Publisher www #2 to #n: URL of the publisher of the paper, e.g., the journal where the paper can be bought or downloaded. To access this internet address, copy and paste the URL into the internet browser.
Link to EFSA Library #2 to #n: address of the paper in the EFSA library, if available.

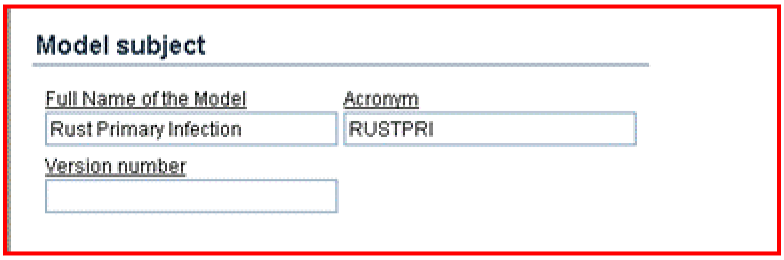
Contact person
This part contains the full address, available on the literature source, of the person to be contacted for any needs about the model (i.e., corresponding author, modeller, responsible party for the model, etc.). Details are listed in the following fields.
Last Name: to be entered as family name.
First Name: to be entered as first name.
Institution: name or official initials of organization.
Department Faculty: department or faculty.
Address: physical address where the organization or individual may be contacted.
Postal Code: postal code (ZIP or other).
City: city of the location.
Country: country (ISO3166-2).
Phone: telephone number for contacting the organization or individual.
Email: email address for contacting the organization or individual.
Fax: fax number for contacting the organization or individual.
Online Contact: on-line information that can be used to contact the individual or organization. For example, this field could contain the URL of a web-page where one can make an online request for information. This field could also contain an email address devoted to receiving requests for information; such email addresses are supplied by many organizations. For example, one can obtain information about publications from the Cambridge University Press by writing to: information@cambridge.org.
Administrator Area: state, province of the location.
Hours Service: time period when individuals can contact the organization or individual.
Contact Instruction: supplemental instructions on how or when to contact the organization or individual.

Chronology
This section contains two fields (see example below), which are filled in automatically by the system.
Profile creation: the date on which the profile was completed (ISO 8601, YYYY-MM-DD).
Profile modification: the date on which the profile was modified (YYYY-MM-DD); this information is automatically updated every time the action "save" is performed.

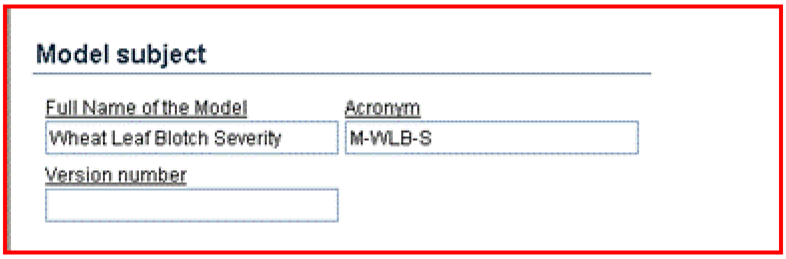


Model subject
This section provides basic information about the model. Details are listed in the following fields.
Full Name of the Model: the selected and agreed upon name of the model, modelling package, or model instance (usually from the original item), if there is any. When a full name of the model is not present in the bibliographic source, a name must be created; the created name should indicate the name of the pathogen and/or host, the type of output, or other main characteristics of the model (see examples below).

Acronym: If the bibliographic source provides an acronym, it should be entered into this field (see example below).



If the bibliographic source does not provide an acronym, one must be created according to the following rules: the acronym must start with an uppercase "M" followed by a dash to identify those models whose acronyms were created within **M**opest (see example below).



Version number: version of model for which the documentation is created (usually from the paper), if there is any.

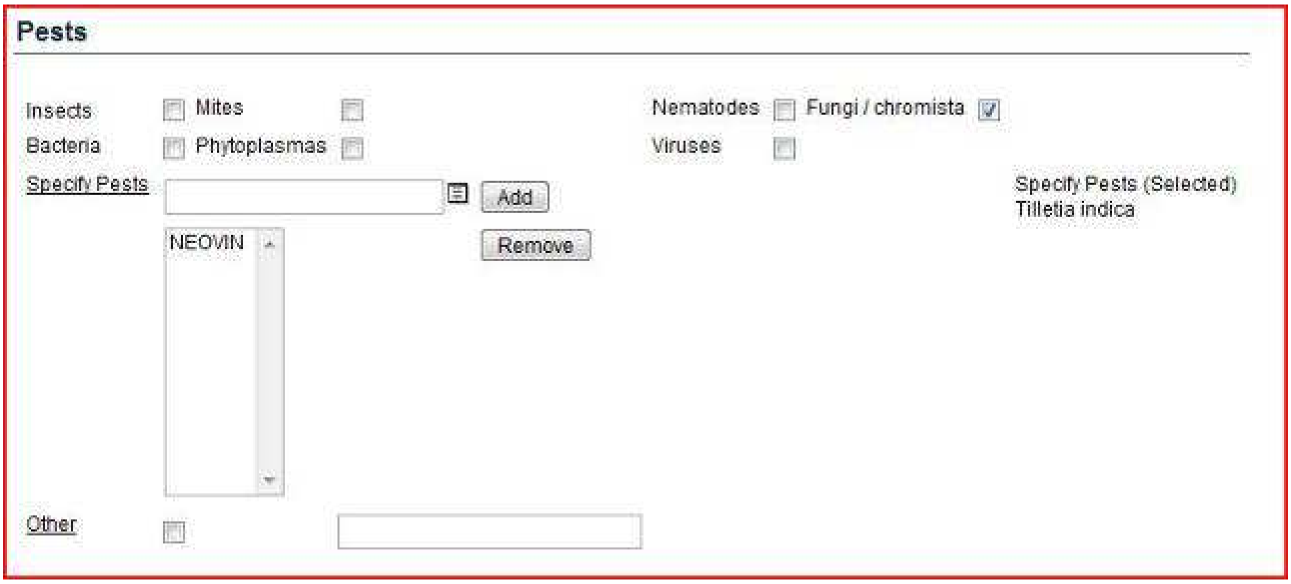
Pests

This section indicates the pest(s) considered in the model (using the EPPO code of each pest) and also indicates the group to which the pest belongs: insects, mites, nematodes, fungi / chromista, bacteria, phytoplasmas, viruses, other to be specified (e.g., Mycoplasma Like Organisms).

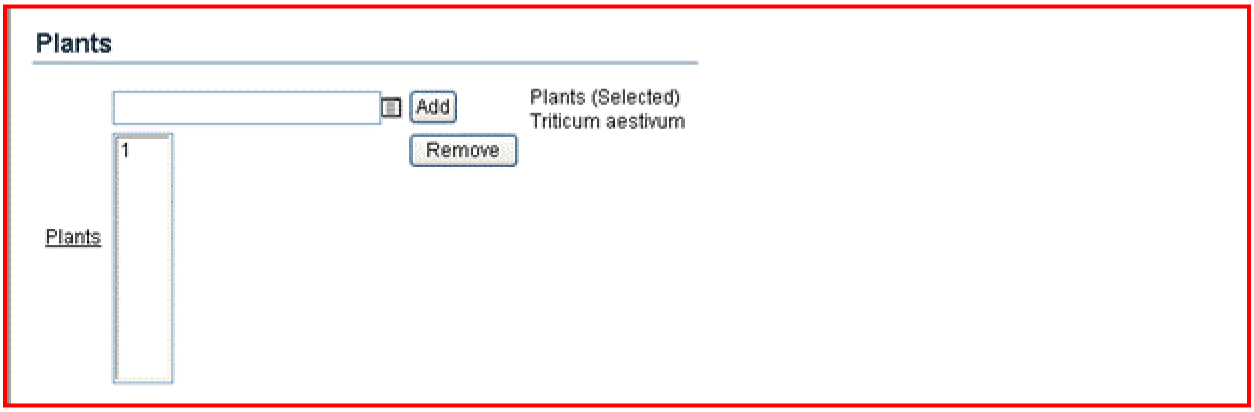
The selection of the group to which the pest under study belongs is performed by means of a Check box (see example below).

Specify Pests: the name of the species under study can be selected from a "Multiple values field". Once the species of the pest has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Specify Pests (Selected)" (see example below).

Other: to be filled in when it is not possible to retrieve the name of the species of the pest from the field "Specify Pests".



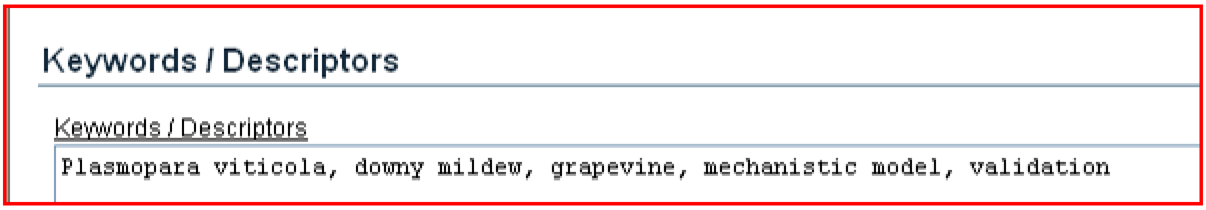
Plants
This section indicates the plant(s) considered in the model, using the EPPO code of each plant.
Plants: the name of the plant host of the pest species under study. The name can be selected from a "Multiple values field". Once the plant has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Plants (Selected)" (see example below). The number represents the descriptor ID, which is useful for database management.



MOPEST 2

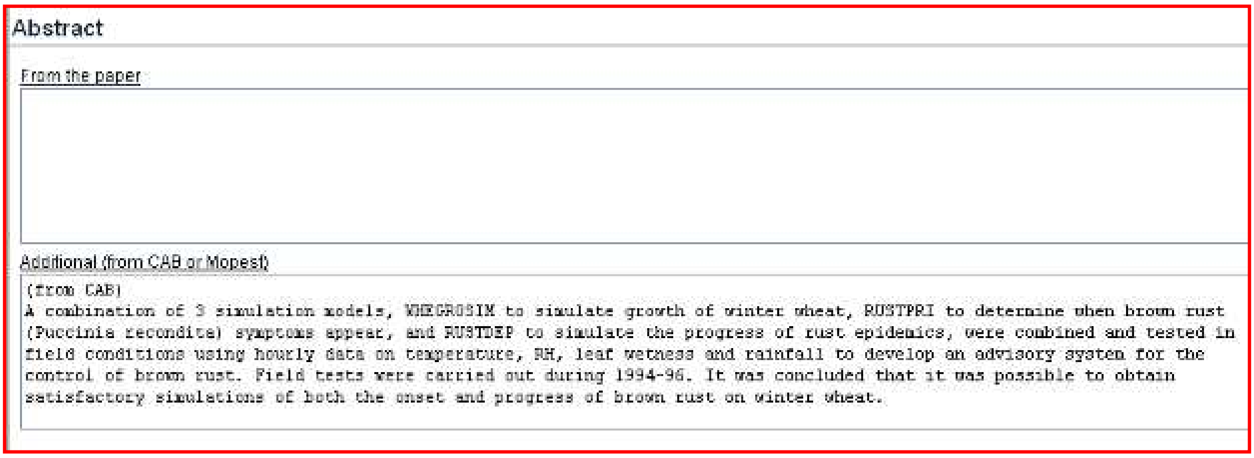
Keywords / Descriptors

Keywords / Descriptors: list of keywords from the paper, to be entered as comma-delimited words (see example below). Original keywords from the paper must be translated into English if they were written in other languages. If keywords are not provided within the original bibliographic source, they must be created (the created keywords should effectively describe the document being considered) and then added here.



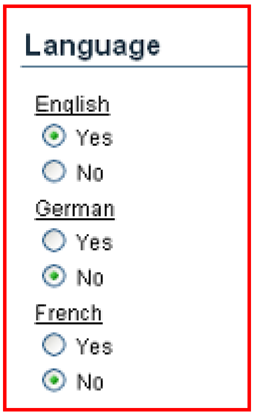
Abstract

From the paper: the original abstract from the published paper.
Additional (from CAB or Mopest): any additional abstract. For example, if the abstract is not present in the original bibliographic sources, the abstract present in CAB can be reported in this section (see example below).



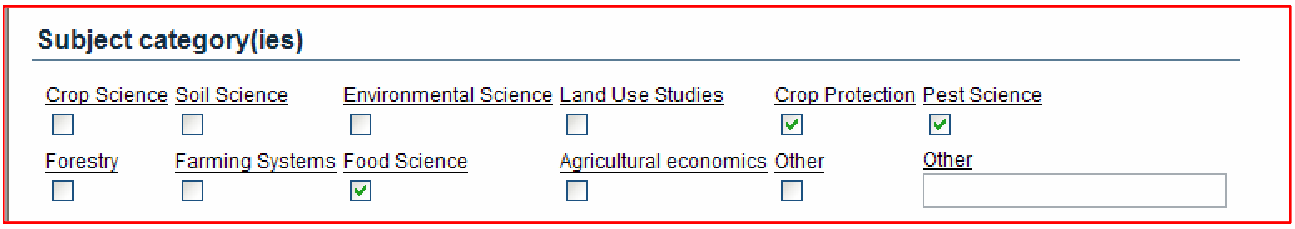
Language

The language(s) of the original document is indicated here. Languages are listed following ISO639-2.
English: the choice (Yes or No) is made by means of a “Radio button” field (see example below).



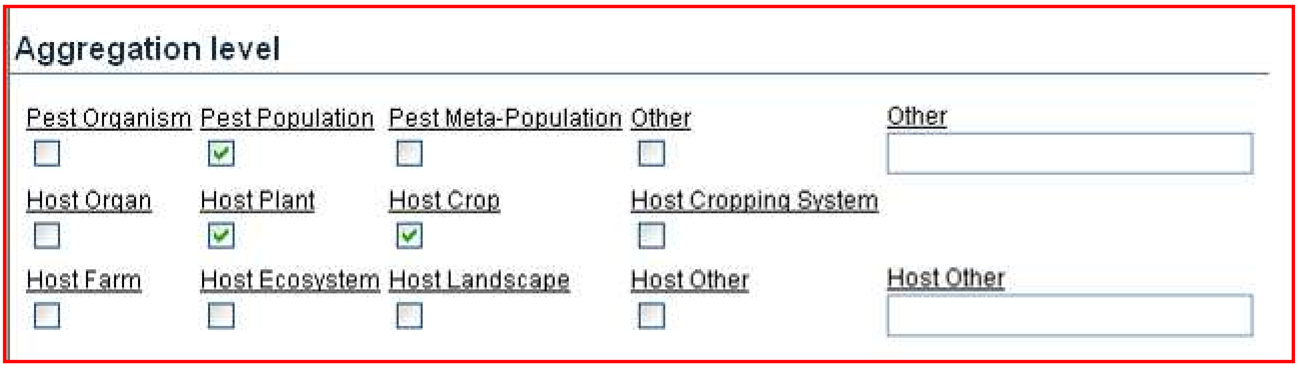
German: the choice (Yes or No) is made by means of a “Radio button” field (see example above).
French: the choice (Yes or No) is made by means of a “Radio button” field (see example above).
Language of the paper: if the paper is written in a language other than English, German, or French, the language of the paper can be selected from a “Multiple values field”. Once the language has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Language(s) (Selected)” (see example below). The number represents the descriptor ID, which is useful for database management.

Subject category(ies)
The broad subject class of the model is indicated in this section. The choice is made by means of a “Check Box” field where all the categories are listed. For example, a model related to mycotoxins will refer to the following categories: Crop protection, Pest Science, and Food Science (see example below).



Aggregation level
The aggregation level of the model is indicated here. The choice is made by means of a “Check Box” field where all the levels are listed (see example below). The levels are listed from the smallest to the largest. For example, the model can focus on the pest organism, on the population (the population of that species present in a field), or on the meta-population (which consists of a group of spatially separated populations of the same species that interact

at some level). With respect to host plant, the model can focus on one organ (e.g., the leaf), on the whole plant, on all the plants present in a field, or on the whole cropping system.



Geographic coverage

The geographic coverage of the model refers to the overall location and sub-locations of the process described in the model. This section indicates whether the model is limited to a specific geographic location. Names of the geographic areas are listed using the ISO 3166-2 code.

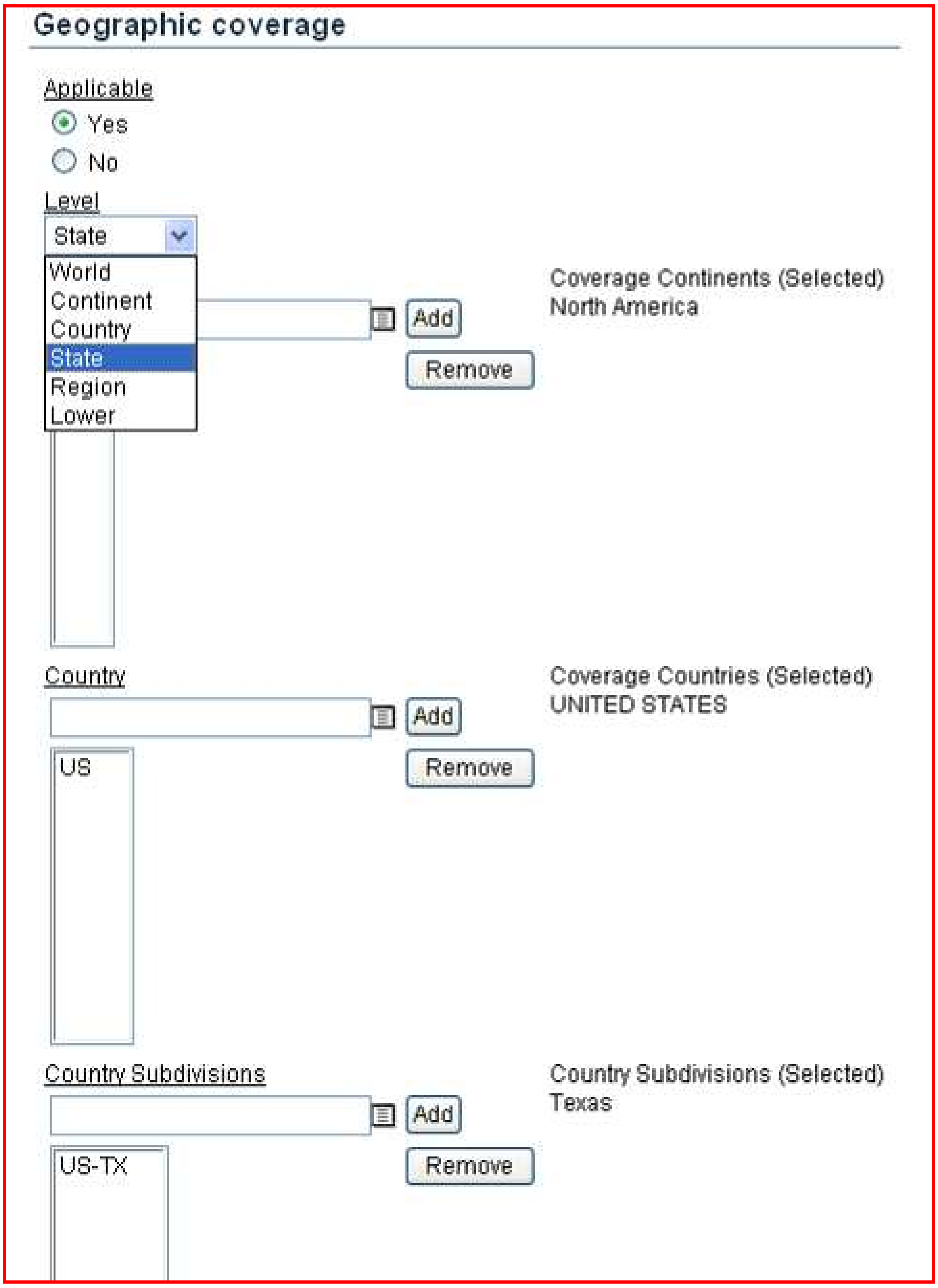
Applicable: is the model limited to a specific geographic location? The choice (Yes or No) is made by means of a "Radio button" field (see example below). For example, empirical models are usually implemented for a defined geographic area.

Level: geographic area covered by the data source. This field is implemented as a "Drop-down box", and the choice is made by marking the highest level within the following options: World, Continent, Country, State, Region, Lower (see example below).

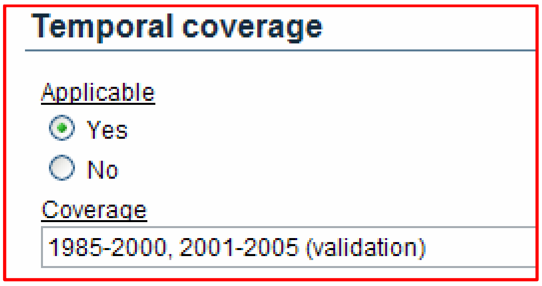
Continents: select the appropriate continent(s). The selection is performed from a "Multiple values field". Once the continent has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Coverage Continents (Selected)" (see example below). The number represents the descriptor ID, which is useful for database management.

Country: the selection is performed from a "Multiple values field". Once the country has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Coverage Countries (Selected)" (see example below). The number represents the descriptor ID, which is useful for database management.

Country Subdivisions: the selection is performed from a "Multiple values field". Once the country subdivision has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Country Subdivisions (Selected)" (see example below). The number represents the descriptor ID, which is useful for database management.



Temporal coverage
The section describes the temporal coverage of the model.
Applicable: has the model been developed and/or tested over a specific interval of time? The choice (Yes or No) is made by means of a “Radio button” field (see example below).
Coverage: the temporal interval over which the model has been developed and/or tested. If the time interval refers to the validation process, this should be specified within brackets (see example below).



Technical specifications

These technical specifications refer to the computerized version of the model, if one exists. Details are listed in the following fields.

Executable Existence: has the model been implemented as an executable file? The choice (Yes or No) is made by means of a “Radio button” field.

Executable Availability: is the executable file (.exe) available? The choice (Yes or No) is made by means of a “Radio button” field.

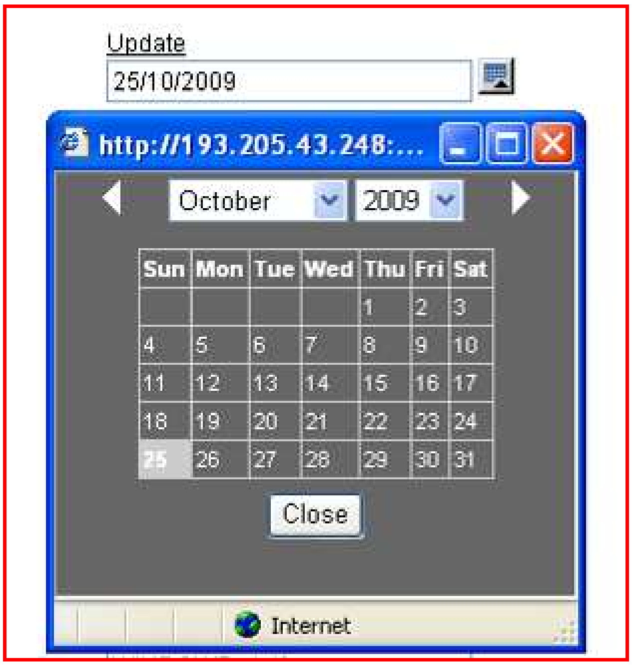
Download Link (URL): URL of the website where the executable file can be downloaded or found. To access this internet address, copy and paste the URL into the internet browser.

Download Made: has a download been made within the Mopest portal? The choice (Yes or No) is made by means of a “Radio button” field; if yes, fill in the next field.

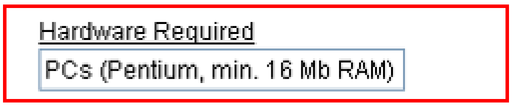
Link where download is stored: URL to access the downloaded executable file within EFSA extranet. To connect to this internet address, copy and paste the URL into the internet browser.

Downloaded Version: version of the downloaded executable file, if there is any.

Update: the last date on which the executable file was updated, YYYY-MM-DD. This information is entered by means of a “Date field”; the corresponding date will be automatically added to the field (see example below).



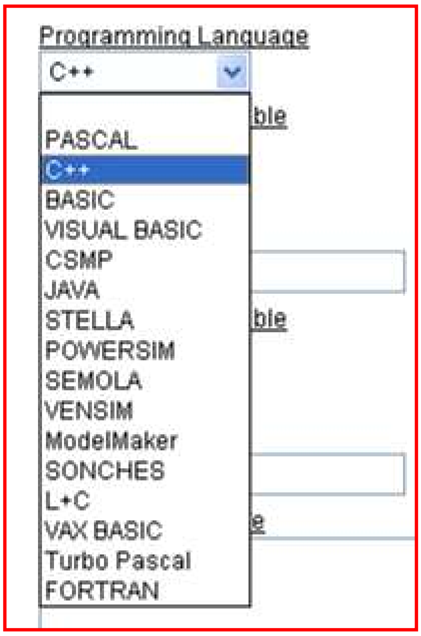
Date Last Download: the date on which the last download of the executable file was made, YYYY-MM-DD. This information is entered by means of a “Date field”; the corresponding date will be automatically added to the field.
Hardware Required: computer hardware (including processor size and/or type and amount of memory space) required to store and operate the model, and recommended configuration (see example below).



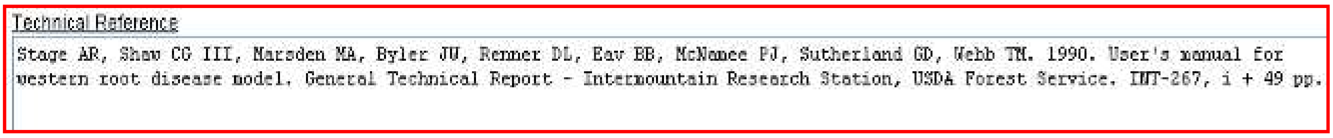
Operating System: the official name of the operating system required to run the model (e.g., DOS, Windows, Linux, Unix, Mac, etc.); the choice is made by means of a “Multi values field”. Once the kind of Operating system has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Operating System (Selected)” (see example below). The number represents the descriptor ID, which is useful for database management. The available list of Operating systems can be extended by accessing the sheet OP SYSTEMS (see the section “Additional fields” at the end of this chapter).

Other Software Requirements: the choice (Yes or No) is made by means of a “Radio button” field (see example below); if yes, provide the official name of the software.
Software Required: official name of the software (see example below).

Programming Language: the computer language in which the modelling software was written. The selection is made by means of a “Drop-down box” field (see example below). This list can be extended by accessing the sheet PROG LANGS (see the section “Additional fields” at the end of this chapter).



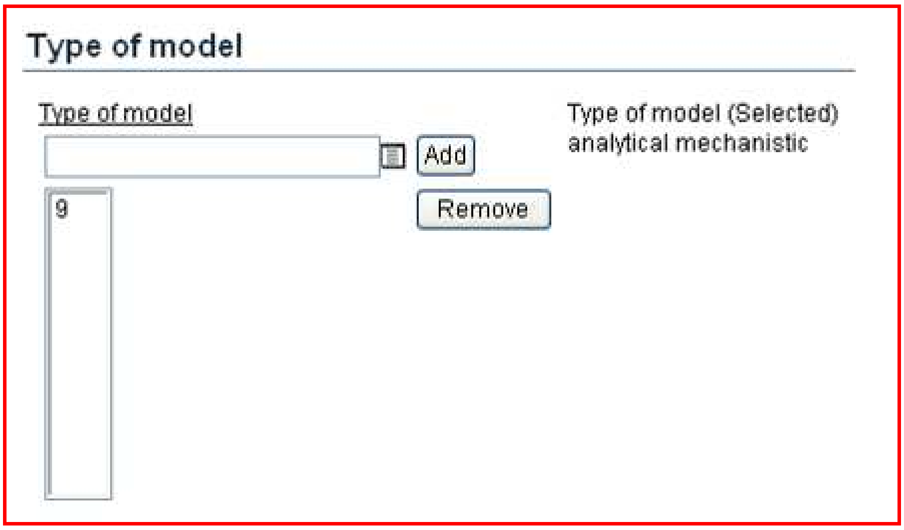
Source Code Available: the choice (Yes or No) is made by means of a “Radio button” field.
Name of PDF file: name of the pdf file (if available) that is stored in the EFSA extranet.
User's Guide Available: the choice (Yes or No) is made by means of a “Radio button” field.
Name of PDF file: name of the User’s Guide pdf file (if available) that is stored in the EFSA extranet.
Technical Reference: if there is a technical reference available (for example, if the User’s Guide is available in the form of a publication), give the full reference (see example below).



User Contract Mandatory: the choice (Yes or No) is made by means of a “Radio button” field.
Remarks/Additional information: any comments about the executable file, including the level of expertise required to download, install, run, and interpret the model.
Access or use Constraints: any access or use constraints or conditions (e.g., none, public domain, limited to specific organizations, available after registry, available after access purchase, for government use only, copyrighted, other).
Contact Name: the full address of the person to be contacted for any need about the executable file (for details, see section “Contact person” in the MOPEST sheet).
Contact Institution: name or official initials of organization.
Contact Administrator Area: state, province of the location.
Contact Address: physical address for contacting the organization or individual.
Contact Postal Code: postal code (ZIP or other).
Contact City: city of the location.
Contact Country: country (ISO3166-2).
Contact Phone: telephone number for contacting the organization or individual.
Contact Fax: fax number for contacting the organization or individual.
Contact Email: email address for contacting the organization or individual.

Contact Online Contact: on-line information that can be used to contact the individual or organization.
Contact Hours Service: time period when individuals can contact the organization or individual.
Contact Instruction: supplemental instructions on how or when to contact the organization or individual.

Type of model
Type of model: the description of the type of model; the choice is made by means of a "Multi values field". Once the type of model has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Type of model (Selected)" (see example below). The number represents the descriptor ID, which is useful for database management.



The available list of model types can be extended by accessing the sheet MODEL TYPES (see the section "Additional fields" at the end of this chapter). The types of model listed are: descriptive, analytical empiric, and analytical mechanistic. Descriptive models are based on known mathematical functions (e.g., the logistic, Gompertz, asymptotic) applied to observed data. Analytical empiric models are those whose structure is determined by the observed relationship among experimental data. Analytical empiric models can be rule-based (e.g., an event occurs when the rule is fulfilled), table-based or graph-based (the output is obtained by means of a table or graph, where the independent variables represent the first row and column or the axes, respectively), equation-based (the model is elaborated on the basis of regression or discriminant analysis), neural network (the model is based on artificial neural networks, which are highly interconnected network structures consisting of many simple processing elements that can perform many parallel computations for data processing), and stochastic (these models include variability in their parameters). Analytical mechanistic models are those that have a structure that explicitly represents an understanding of physical, chemical, and/or biological processes.

Scientific model specifications
This section provides information about the scientific aspects of the model. Details are listed in the following fields.

Flow Diagram (name of PDF file): if a flow diagram exists, insert the name of the corresponding pdf file, available within EFSA extranet. As a convention, this pdf file must be named using the following format: ModelAcronym_FlowDiagram.pdf.
Mathematical Information: the description of the steps or equations used by the model to transform and or manipulate the model inputs to the output data. List the algorithm(s) used in the model. When reporting this information, it is necessary to quote the exact page from where the information was extracted. If equations are reported, they must be written according to the Excel format (e.g., the multiplication operator is “*”; the power operator is “^”); moreover, if the equations reported are numbered in the paper of origin, their identification number must be reported in this text area (see example below).

Mathematical Information

```
Severity is calculated according to the following equation (from page 1248, equation 2):
 y = 147.480 - 3.025*X1 - 2.093*X2
where:
X1 = the total consecutive days without precipitation between 26 March and 4 May;
X2 = the total consecutive days between 4 April and 3 May with minimum temperature equal
to or less than 7 C.
```

Assumption(s): the information about the assumptions made for abstracting the model from reality (see example below). If no assumptions are stated in the original manuscript, this field must be left empty. The page from where the information was taken must be reported.

Assumption(s)

```
From page 421, second column:

The model assumes that, in a wheat-growing area, the inoculum is always present
in equal doses for all the pathogens responsable of wheat Fusarium  head blight
(Gibberella zea, Fusarium culmorum, Gibberella avenacea, Monographella nivalis).
```

Model Uncertainty: the imperfect knowledge (regarding the system to be modelled or concerning the model formulation) that can trigger uncertainty of the model outputs. This field must be filled only if sources of uncertainty are cited within the model description (see example below). The page from where the information was taken must be reported.

Model Uncertainty

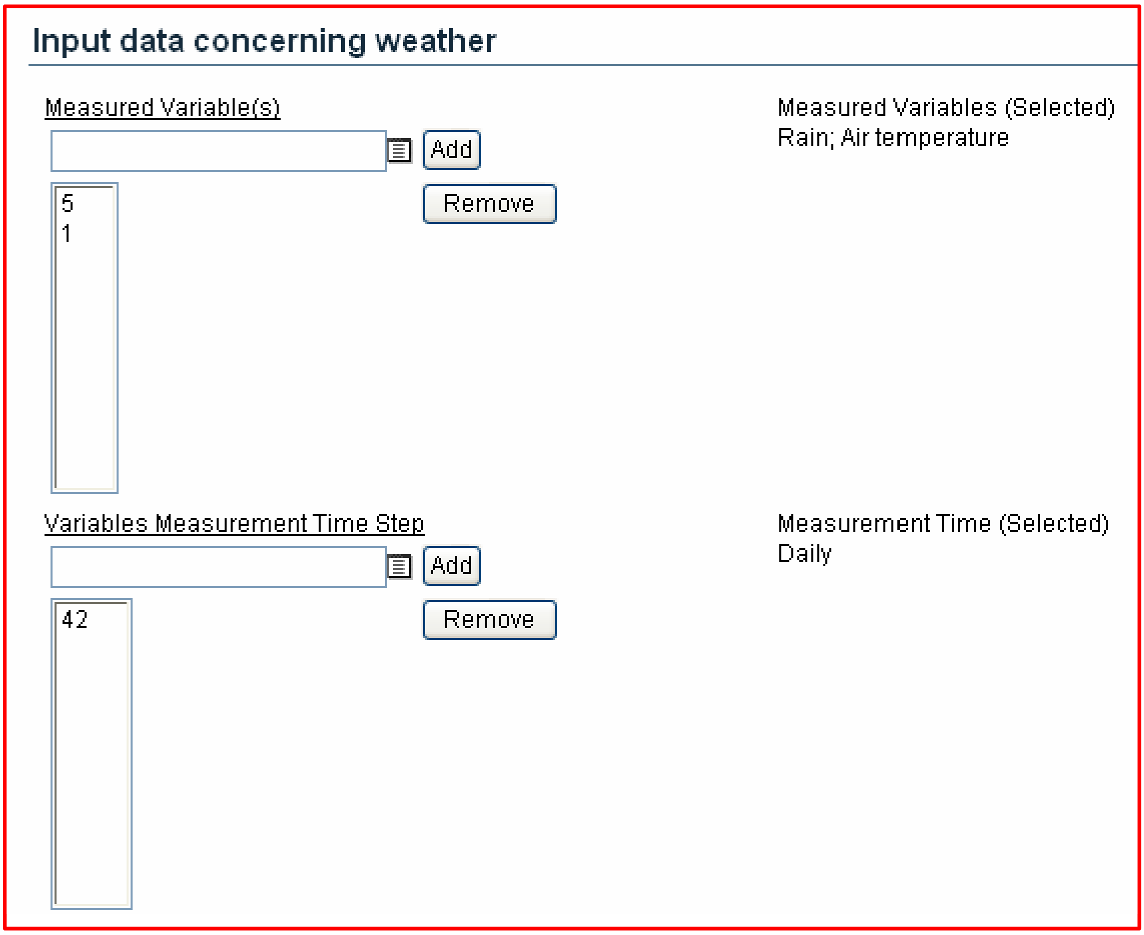
```
From page 434, second half of the first column:

The model predictions can be influenced by unusually wet conditions outside the 17-day
time period, or precipitation conditions not considered by the model; therefore, prediction
will never be 100% accurate. Thus, predictions will be subject to uncertainty about weather
conditions in subsequent time periods.
```

Mopest 3

Input data concerning weather

The description of the weather data set required by the model is provided within the following fields.

Measured Variable(s): list of the necessary meteorological variables (e.g., air or soil temperature, relative humidity, rain, wetness, etc.); the choice is made by means of a "Multi values field". Once the kind of Measured Variable has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Measured Variables (Selected)" (see example below). The number represents the descriptor ID, which is useful for database management. The available list of Measured Variables can be extended by accessing the sheet MEAS VARS WEATHER (see the section "Additional fields" at the end of this chapter).

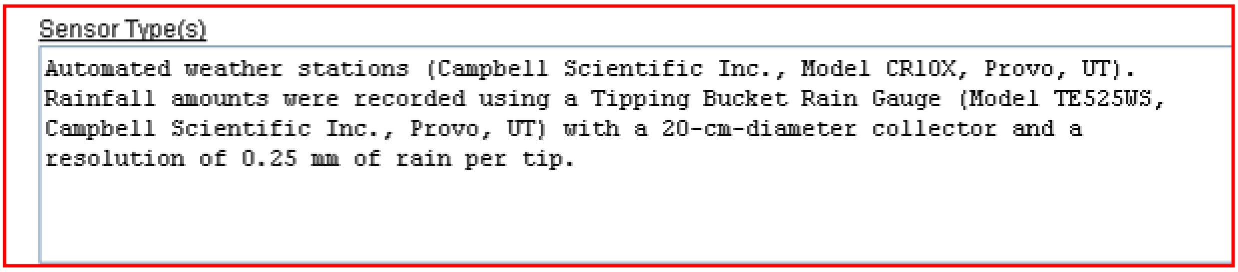


Variables Measurement Time Step: the time step at which the variable was measured, according to the standards in the WMO Data Frequency Code. The choice of the time step is made by means of a "Multi values field". Once the kind of time step has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Measurement Time (Selected)" (see example above). The number represents the descriptor ID, which is useful for database management. The list of Measurement Time steps includes the following:

- Continuous: data is measured continuously;

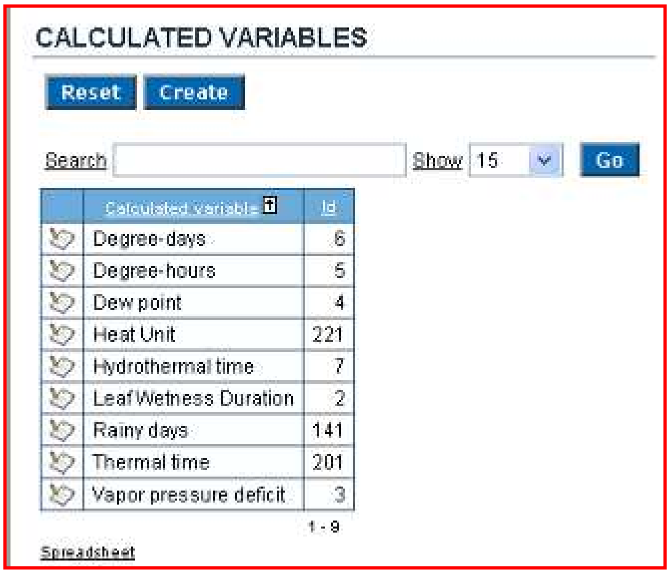
- Daily: data is measured every day;
- Weekly: data is measured every week;
- Fortnightly: data is measured every 2 weeks;
- Monthly: data is measured every month;
- Quarterly: data is measured every 3 months;
- Biannually: data is measured twice each year;
- Annually: data is measured every year;
- As Needed: data is measured when there is the need for the data;
- Irregular: data is measured irregularly;
- Not Planned: the time step for measurements is not planned;
- Unknown: no specifications about the time step are supplied;
- Hourly: data is measured every hour;
- 3-Hourly: data is measured every 3 hours;
- 6-Hourly: data is measured every 6 hours;
- 12-Hourly: data is measured every 12 hours.

<u>Sensor Type(s)</u>: the kind of sensor(s) used, the unit of measure of the measured variable(s), and any other available information (see example below).

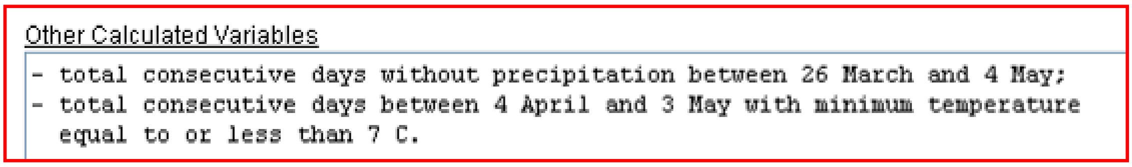


<u>Sensor Location</u>: where the sensors were located (e.g., outside the crop, inside the crop, within the canopy); the choice is made by means of a “Multi values field”. Once the location of the sensor has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Sensor Location (Selected)”. The number represents the descriptor ID, which is useful for database management. The available list of Sensor Location can be extended by accessing the sheet SENSOR LOCATIONS (see the section “Additional fields” at the end of this chapter).

<u>Calculated Variables</u>: the input variables calculated from measured variables; the choice is made by means of a “Multi values field”. Once the kind of Calculated Variable has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Calculated Variables (Selected)”. The number represents the descriptor ID, which is useful for database management. The available list of Calculated Variables (reported below) can be extended by accessing the sheet CALC VARS WEATHER (see the section “Additional fields” at the end of this chapter).

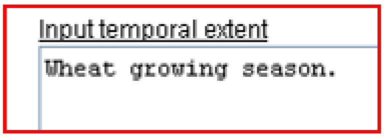


Other Calculated Variables: calculated variables that are specific to the model under consideration and that are unlikely to have been used by other models (e.g., average values calculated over the specific period considered by the model) (see example below).



Input time step: the time step at which the variable is included into the model, according to WMO Data Frequency Code (see the list provided in the "Input data concerning weather" section); the choice is made by means of a “Multi values field”. Once the input time step has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Measurement Time (Selected)”. The number represents the descriptor ID, which is useful for database management.

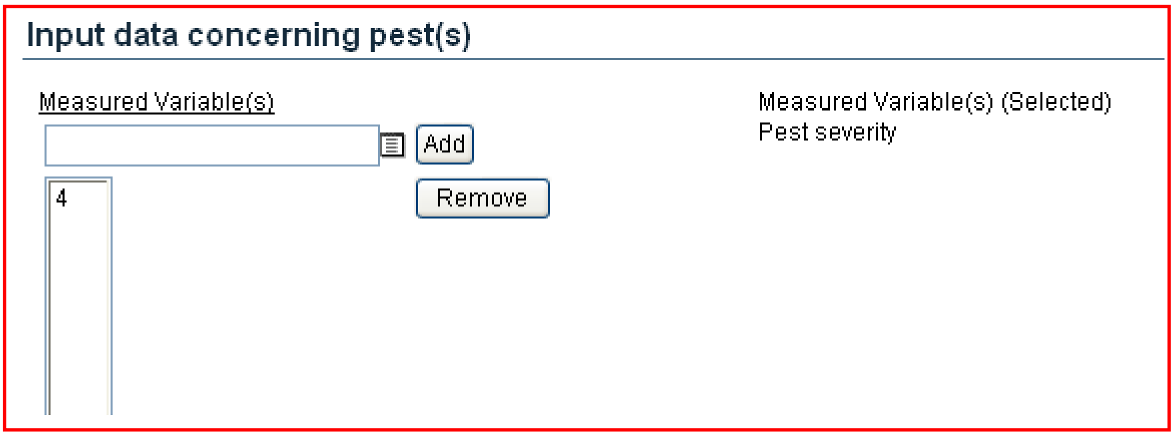
Input temporal extent: the duration of the total relevant period of time required or recommended for running the model (see example below).



Input data concerning pest(s)

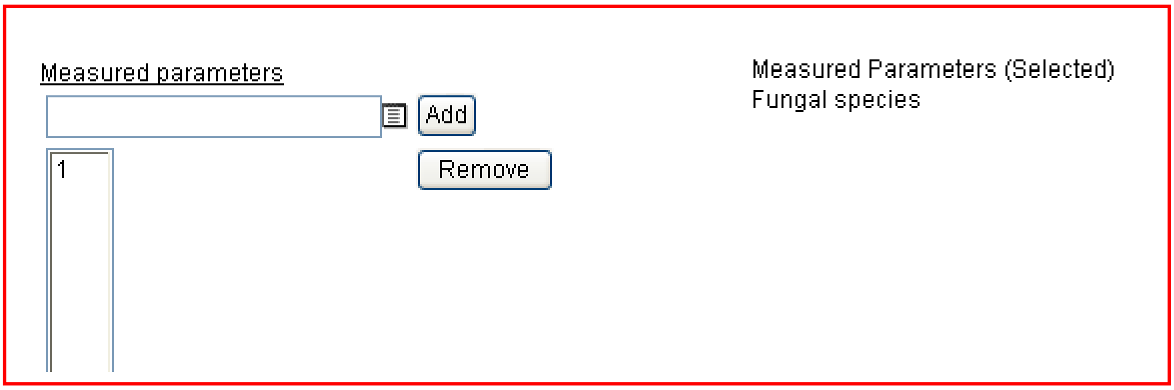
The description of the data set concerning pest(s) that is required in the processing of the model is provided within the following fields.

Measured Variable(s): list the necessary variables (e.g., inoculum density, pest presence, pest incidence, pest severity, etc.); the choice is made by means of a “Multi values field”. Once the kind of Measured Variable has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Measured Variables (Selected)” (see example below). The number represents the descriptor ID, which is useful for database management. The available list of Measured Variables can be extended by accessing the sheet PEST VARIABLES (see the section “Additional fields” at the end of this chapter).

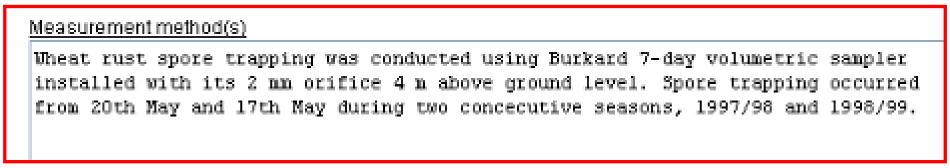


Variables Measurement Time Step: the time step at which the variable was measured, according to WMO Data Frequency Code (see the list provided in the "Input data concerning weather" section). The choice of the measurement time step is made by means of a “Multi values field”. Once the kind of Measured Time Step has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Measurement Time (Selected)”. The number represents the descriptor ID, which is useful for database management.

Measured parameters: the pest parameters, i.e., those factors that are measured once for each simulation and that do not vary during the simulation (e.g., Fungal species, Inoculum density, Pest initial population, etc.); the choice is made by means of a “Multi values field”. Once the kind of Measured parameters has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Measured Parameters (Selected)” (see example below). The number represents the descriptor ID, which is useful for database management. The available list of Measured parameters can be extended by accessing the sheet MEASURED PARAMETER PEST (see the section “Additional fields” at the end of this chapter).

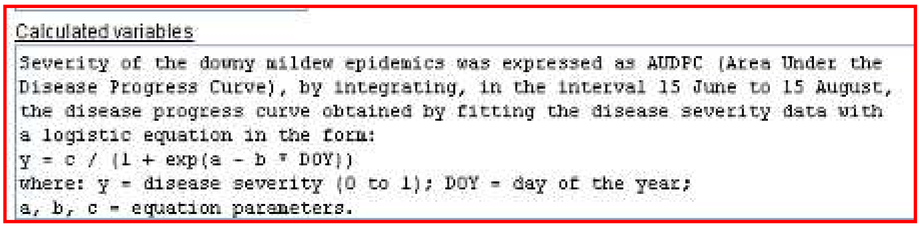


Measurement method(s): details about the method(s) used for variable measurement, quantification or assessment (e.g., kind of spore sampler, kind of scale used for severity assessment, etc.); the unit of measure; and any other available information. Insert in the next field the name of the documentation pdf file stored within the EFSA extranet, if such a file exists.


Measurement method(s)

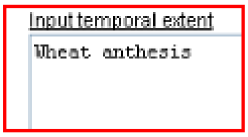
Wheat rust spore trapping was conducted using Burkard 7-day volumetric sampler installed with its 2 mm orifice 4 m above ground level. Spore trapping occurred from 20th May and 17th May during two concecutive seasons, 1997/98 and 1998/99.

Documentation (name of PDF file): name of the documentation pdf file stored within the EFSA extranet.
Calculated variables: the input variables calculated from measured variables (e.g., area under disease progress curve, daily spore counts: sum of 24 hourly records, etc.).


Calculated variables

Severity of the downy mildew epidemics was expressed as AUDPC (Area Under the Disease Progress Curve), by integrating, in the interval 15 June to 15 August, the disease progress curve obtained by fitting the disease severity data with a logistic equation in the form:
y = c / (1 + exp(a - b * DOY))
where: y = disease severity (0 to 1); DOY = day of the year;
a, b, c = equation parameters.

Input time step: the time step at which the variable is included in the model, according to WMO Data Frequency Code (see the list provided in the "Input data concerning weather" section); the choice is made by means of a “Multi values field”. Once the input time step has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Measurement Time (Selected)”. The number represents the descriptor ID, which is useful for database management.
Input temporal extent: the duration of the total relevant period of time required or recommended (see example below).


Input temporal extent

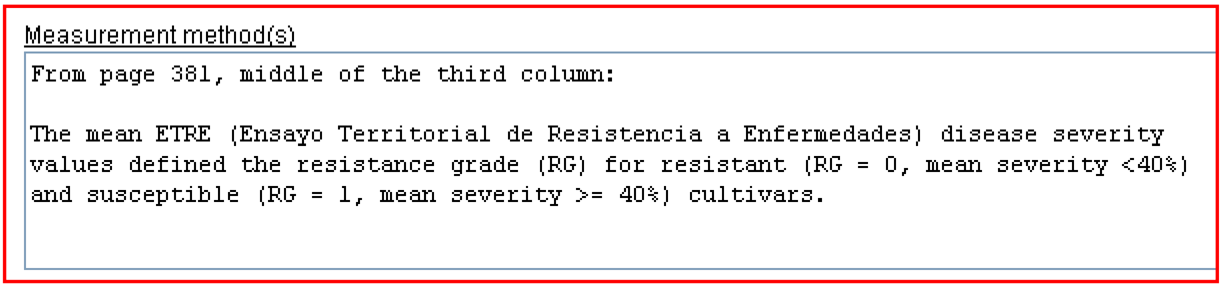
Wheat anthesis

Input data concerning crop(s)
The description of the data set concerning crop(s), as required in the processing of the model, is provided within the following fields.
Measured Variable(s): list the necessary variables (e.g., growth stage, leaf area, free water in the host tissue, etc.); the choice is made by means of a “Multi values field”. Once the kind of Measured Variable has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Measured Variables (Selected)” (see example below). The number represents the descriptor ID, which is useful for database management. The available list of Measured Variables can be extended by accessing the sheet HOST VARS (see the section “Additional fields” at the end of this chapter).

Variables Measurement Time Step: the time step at which the variable was measured, according to WMO Data Frequency Code (see the list provided in the "Input data concerning weather" section). The choice of the measurement time step is made by means of a "Multi values field". Once the kind of Measured Time Step has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Measurement Time (Selected)". The number represents the descriptor ID, which is useful for database management.

Measured parameters: crop parameters (e.g., Maximum leaf area, Host species, Resistance to disease, Sowing date, Cultivar, etc.) are measured once for each simulation, and they do not vary during the simulation; the choice is made by means of a "Multi values field". Once the kind of Measured parameters has been chosen and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Measured Parameters (Selected)" (see example below). The number represents the descriptor ID, which is useful for database management. The available list of Measured parameters can be extended by accessing the sheet MEASURED PARAMETER CROP (see the section "Additional fields" at the end of this chapter).

Measurement method(s): details on the method(s) used for variable measurement, quantification, or assessment (e.g., leaf area meter, biomass, BBCH scale, etc.); the unit of measure; and any other available information (see example below). Insert in the next field the name of the documentation pdf file stored within the EFSA extranet, if such a file exists.



Documentation (Name of PDF file): name of the documentation pdf file stored within the EFSA extranet.

Calculated Variables: the input variables calculated from measured variables (e.g., Leaf Area Index, biomass produced per day, etc.) (see example below).

Calculated variables

```
During leaf expansion, the leaf area (LA) on each z day is calculated as follows,
up to a maximum value (MaxLA):
LAz = LAz-1 + (DLAEz * LLR)
where: DLAE = daily increase of leaf (sheat and lamina) area (cm2*d^-1) during expansion;
LLR = ratio between lamina and leaf.
DLAE is a function of mean air temperature (Tm). It is calculated by a polynomial regression:
DLAEz = - 0.2623 + 0.4140 * Tmz - 0.0948 * Tmz^2 + 0.0101 * Tm z^3 - 0.0003 * Tmz^4
```

Input time step: the time step at which the variable is included in the model, according to WMO Data Frequency Code (see the list provided in the "Input data concerning weather" section); the choice is made by means of a “Multi values field”. Once the input time step has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Measurement Time (Selected)”. The number represents the descriptor ID, which is useful for database management.
Input temporal extent: the duration of the total relevant period of time required or recommended.

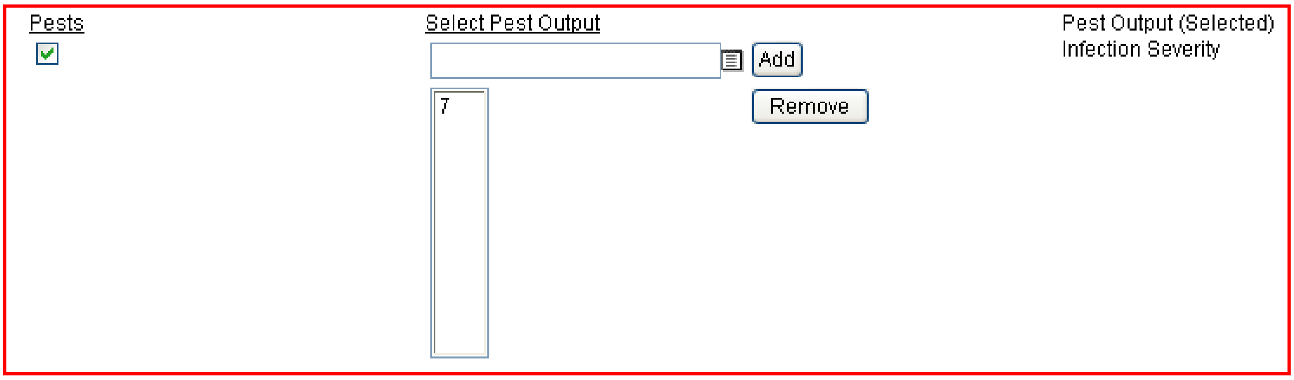
Output
This section concerns model output.

Output(s) description: the list and description of the model output(s), their unit(s) of measure, and any other available information (see example below).

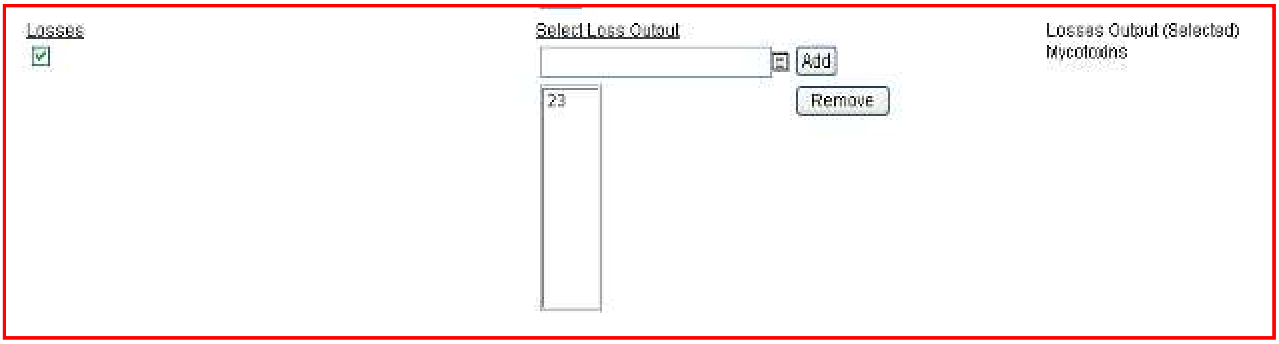
Output(s) description

```
The equations estimate the percentage of leaf rust severity.
```

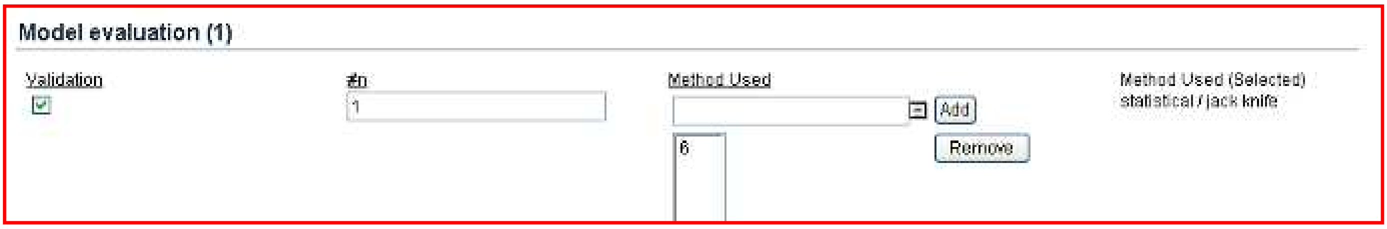
Output time step: the time step at which the variable is used in the model, according to WMO Data Frequency Code (see the list provided in the "Input data concerning weather" section); the choice is made by means of a “Multi values field”. Once the input time step has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Measurement Time (Selected)”. The number represents the descriptor ID, which is useful for database management.
Output temporal extent: the duration of the total period of time required or recommended.
Pests: does the model’s output refer to the pest? If yes, tick this check box.
Select Pest Output: choose the kind of output (e.g., pest onset, pest density, infection occurrence, infection severity, disease onset, disease incidence, disease severity, etc.); the choice is made by means of a “Multi values field”. Once the pest output has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Pest Output (Selected)”. The number represents the descriptor ID, which is useful for database management. The available list of Pests Outputs can be extended by accessing the sheet PESTS OUTPUTS (see the section “Additional fields” at the end of this chapter).



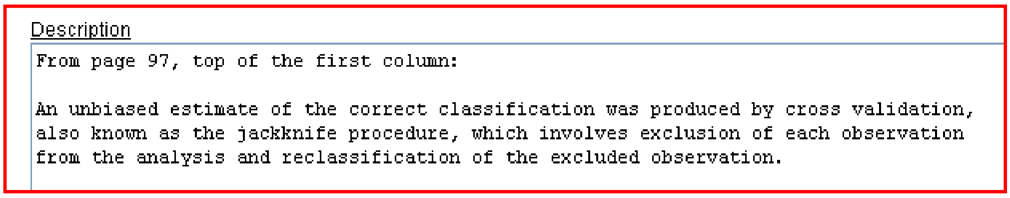
Losses: does the model's output refer to losses? If yes, tick the check box.
Select Loss Output: choose the kind of output (e.g., yield, quality, mycotoxin, money, biodiversity, Leaf Area Index, etc.); the choice is made by means of a "Multi values field". Once the loss output has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Losses Output (Selected)". The number represents the descriptor ID, which is useful for database management. The available list of Losses Outputs can be extended by accessing the sheet LOSSES OUTPUTS (see the section "Additional fields" at the end of this chapter).



Model evaluation (1)
Model evaluation is the judgement of the overall adequacy of the model. Evaluation includes several activities. Details are listed in the following fields.
Validation: insert information about procedures used for evaluating the ability of the model to reproduce the behaviour of the real world. If a validation was performed, tick this check box.
#n: insert the ID number of the reference where the validation is described; if this is included in the main reference, insert the number 1; otherwise, insert the ID number of the related reference where the validation is described.
Method Used: choose the kind of method used for the validation (e.g., Empirical / visual, Empirical / expert judgment, statistical / jack knife, statistical / cross-validation, statistical / regression observed vs. predicted, etc.); the choice is made by means of a "Multi values field" (see example below). Once the method has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Method Used (Selected)". The number represents the descriptor ID, which is useful for database management. The available list of Method Used can be extended by accessing the sheet METHOD USED (see the section "Additional fields" at the end of this chapter).



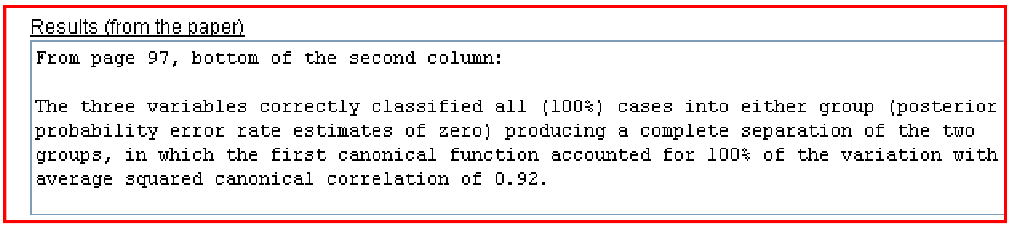
Verification: insert information about procedures used for the inspection of the internal consistency of the model. If a verification was performed, tick this check box.
#n: insert the ID number of the reference where the verification is described; if this is included in the main reference, insert the number 1; otherwise, insert the ID number of the related reference where the verification is described.
Method Used: choose the kind of method used for the verification (e.g., analysis of dimensions and units, detection of violation of natural ranges of parameters and variables, etc.); the choice is made by means of a “Multi values field”. Once the method has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under “Method Used (Selected)”. The number represents the descriptor ID, which is useful for database management. The available list of Method Used can be extended by accessing the sheet METHOD USED (see the section “Additional fields” at the end of this chapter).
Description: insert the description of the validation and/or verification. When portions of text are copied and pasted from the paper to this text area, the page from where the information is taken must be reported (see example below).


Description

From page 97, top of the first column:

An unbiased estimate of the correct classification was produced by cross validation, also known as the jackknife procedure, which involves exclusion of each observation from the analysis and reclassification of the excluded observation.

Results (from the paper): insert here the results obtained from the validation and/or verification process as described in the paper. When portions of text are copied and pasted from the paper to this text area, the page from where the information is taken must be reported (see example below).


Results (from the paper)

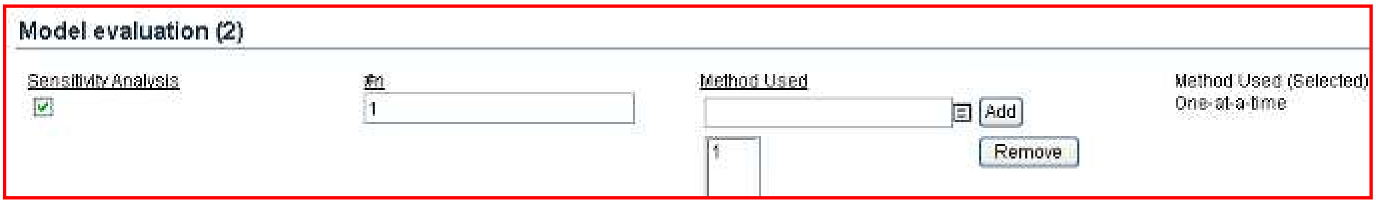
From page 97, bottom of the second column:

The three variables correctly classified all (100%) cases into either group (posterior probability error rate estimates of zero) producing a complete separation of the two groups, in which the first canonical function accounted for 100% of the variation with average squared canonical correlation of 0.92.

Documentation (name of PDF file): name of the documentation pdf file stored within the EFSA extranet.
Results (additional): any additional results.

Model evaluation (2)

Sensitivity Analysis: insert information about the procedures used for sensitivity analysis, i.e., the study of model properties through changes in the input variables and the analysis of its effect on model outputs. If a sensitivity analysis was performed, tick this check box.
#n: insert the ID number of the reference where the sensitivity analysis is described; if this is included in the main reference, insert the number 1; otherwise, insert the ID number of the related reference where the sensitivity analysis is described.
Method Used: choose the kind of method used for the sensitivity analysis (e.g., one-at-a-time, factorial, differential [or local], elicitation, etc.); the choice is made by means of a "Multi values field" (see example below). Once the method has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Method Used (Selected)". The number represents the descriptor ID, which is useful for database management. The available list of Method Used can be extended by accessing the sheet METHOD USED (see the section "Additional fields" at the end of this chapter).



Uncertainty Analysis: insert imperfect knowledge regarding parameters, constants, input data, and assumptions of the model. If an uncertainty analysis was performed, tick this check box.
#n: insert the ID number of the reference where the uncertainty analysis is described; if this is included in the main reference, insert the number 1; otherwise, insert the ID number of the related reference where the uncertainty analysis is described.
Method Used: choose the kind of method used for the uncertainty analysis; the choice is made by means of a "Multi values field". Once the method has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Method Used (Selected)". The number represents the descriptor ID, which is useful for database management. The available list of Method Used can be extended by accessing the sheet METHOD USED (see the section "Additional fields" at the end of this chapter).
Calibration: insert information about the procedures used to adjust some model parameters such that model behaviour matches the set of real-world data considered. If a calibration was performed, tick this check box.
#n: insert the ID number of the reference where the calibration is described; if this is included in the main reference, insert the number 1; otherwise, insert the ID number of the related reference where the calibration is described.
Method Used: choose the kind of method used for the calibration; the choice is made by means of a "Multi values field". Once the method has been selected and the selection has been saved, the content of the selection will be visible on the right side of the sheet under "Method Used (Selected)". The number represents the descriptor ID, which is useful for database management. The available list of Method Used can be extended by accessing the sheet METHOD USED (see the section "Additional fields" at the end of this chapter).
Description: insert the description of the sensitivity analysis and/or uncertainty analysis and/or calibration. When portions of text are copied and pasted from the paper to this text area, the page from where the information is taken must be reported (see example below).

Description

From page 194, "Parameter sensitivity analyses" section:

Sensitivity analyses investigated the effects on model predictions of a range of values for a given parameter. This determined the relative importance of each and confirmed that the parameter values chosen were appropriate for the entire dataset. The ranges tested were representative of those encountered in crops or field experiments. The outputs were displayed graphically, providing insight into particular variables of the system.

Results (from the paper): insert here the results obtained from the sensitivity analysis and/or uncertainty analysis and/or calibration process as described in the paper. If this information is not present in the paper, leave this text area empty. When portions of text are copied and pasted from the paper to this text area, the page from where the information is taken must be reported (see example below).

Results (from the paper)

From page 198, "Parameter sensitivity analyses" section:

Results confirmed that the proportion of immigrating aphids carrying BYDV, the sowing date of the wheat and the time of first arrival of aphids were the major determinants of the rate of BYDV spread, its final incidence and the resulting magnitude of yield loss

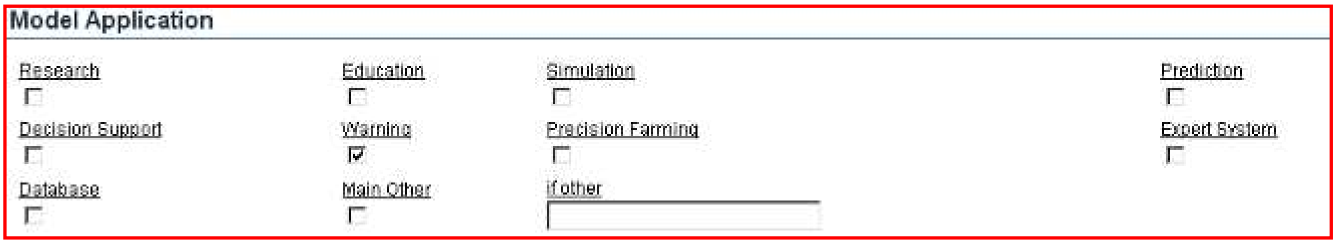
Documentation (name of PDF file): name of the documentation pdf file stored within the EFSA extranet.
Results (additional): any additional results.

Mopest 4

Model application(s)

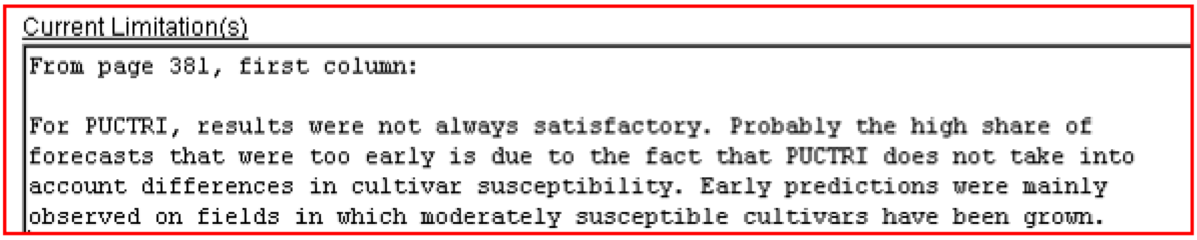
This section provides information about the practical application, current limitations, and perspectives of the model. Details are listed the following fields.

Field of application(s): the main purpose for which the model was developed and its current field of application(s); the choice is made by means of a "check box field" with the following choices: research, education, simulation, forecasting / prediction, decision making, warning, precision farming, expert system, other (specify). For example, a model that produces as output an index of the potential risk of infection can be used within a warning system (see example below).


Model Application

Research ☐	Education ☐	Simulation ☐	Prediction ☐
Decision Support ☐	Warning ☑	Precision Farming ☐	Expert System ☐
Database ☐	Main Other ☐	if other	

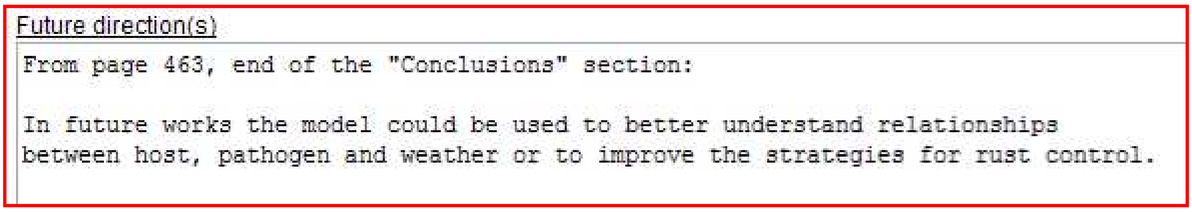
Current limitation(s): drawbacks to parts of the model based on the developer's observations or based on published literature about the model (related references). When portions of text are copied and pasted from the paper to this text area, the page from where the information is taken must be reported (see example below).


Current Limitation(s)

From page 381, first column:

For PUCTRI, results were not always satisfactory. Probably the high share of forecasts that were too early is due to the fact that PUCTRI does not take into account differences in cultivar susceptibility. Early predictions were mainly observed on fields in which moderately susceptible cultivars have been grown.

Future direction(s): the potential future direction of work on the model based on the developer's observations. When portions of text are copied and pasted from the paper to this text area, the page from where the information is taken must be reported (see example below).


Future direction(s)

From page 463, end of the "Conclusions" section:

In future works the model could be used to better understand relationships between host, pathogen and weather or to improve the strategies for rust control.

Suggestion for proper use(s): any suggestion for the possible uses of the model. When portions of text are copied and pasted from the paper to this text area, the page from where the information is taken must be reported (see example below).

Suggestion(s) for proper use

From page 248, first column ("Concluding remarks" section):

The model represents a reliable help for decision making. Only advisers and farmers know the prevailing conditions such as disease incidence and susceptibility of the host plant. With the infection probability as additional information, they gain more knowledge for making the rights decisions.

Notes

Note(s): include in this field notes and observations on the proper use or limitations of the model after having personally applied it.

SUMMARY SHEETS

The summary sheets allow the user to print the model information; see paragraph 2.1.3 for instructions on how to use these sheets.

ADDITIONAL SHEETS

If a required descriptor is not listed among the available ones, the choices in a multi-choice field can be extended by accessing the following sheets: MODEL TYPES, OP SYSTEMS, PROG LANGS, CALC VARS WEATHER, HOST VARS, MEAS VARS WEATHER, METHOD USED, PEST VARIABLES, SENSOR LOCATIONS, PUBLICATION TYPES, PESTS OUTPUTS, LOSSES OUTPUTS, MEASURED PARAMETER PEST, and MEASURED PARAMETER CROP.

The description of these sheets is provided in section 2.2.2. To edit the existing entries, follow the instructions in section 2.2.2.2. To add new entries, perform the steps described in section 2.2.3.

Literature cited

FAO, 2008. Glossary of phytosanitary terms, International Standards for Phytosanitary Measures ISPM no. 5.

Zins C, 1999. Success - structured search strategy: information retrieval in the age of global information systems. 65th IFLA Council and General Conference, Bangkok, Thailand, 20 – 28 August, 1999.

Annex 1

Systematic literature search – Examples from the feasibility study on wheat

Literature search strategy

What

The literature was searched for models that simulate wheat pests in terms of presence/absence, prevalence, incidence, or severity and as a function of weather variables. The pests considered are listed below:

- karnal bunt (*Tilletia* = *Neovossia indica*)
- ergot (*Claviceps purpurea*)
- leaf rust (*Puccinia recondita*)
- powdery mildew (*Blumeria graminis*)
- leaf and glume blotch (*Septoria tritici* and *Stagonospora nodorum*)
- Fusarium head blight and related mycotoxins (*Fusarium* spp.)
- bacterial leaf streak (*Xanthomonas translucens* pv. *translucens*)
- barley yellow dwarf virus
- *Agriotes* spp
- Russian wheat aphid (*Diuraphis noxia*)
- cereal leaf beetle (*Oulema melanopus*)

Where

The bibliographic search was carried out in the CAB Abstracts (from 1972 to 2008), which was accessed by means of the Millennium Web Catalogue of the Università Cattolica.

Words

The rules and tips listed in paragraph 1.1, sub-section Words, were followed. The chart below lists the combination of keywords (formatted according to the syntax rules of CAB Abstracts) used for each pest under study.

Disease/Pest	Key Words
Bacterial leaf streak	(xanthomonas translucens OR bacterial leaf streak) AND wheat AND (model OR simulation OR prediction OR forecast)
Powdery mildew	(blumeria graminis OR erysiphe graminis OR powdery mildew) AND wheat AND (model OR simulation OR prediction OR forecast)
Leaf rust	(brown rust OR puccinia recondita) AND wheat AND (model OR simulation OR prediction OR forecast)
Leaf and glume blotch	(septoria tritici OR mycosphaerella graminicola OR septoria nodorum OR stagonospora nodorum OR leaf blotch OR glume blotch) AND wheat AND (model OR simulation OR prediction OR forecast)
Karnal bunt	(tilletia indica OR neovossia indica OR karnal bunt) AND wheat AND (model OR simulation OR prediction OR forecast)
FHB and mycotoxins	
Fusarium head blight	(gibberella zeae OR fusarium graminearum OR fusarium head blight OR wheat scab) AND wheat AND (model OR simulation OR prediction OR forecast)
Fusarium spp. and related mycotoxins	mycotoxin AND wheat AND (fusarium OR gibberella) AND (model OR simulation OR prediction OR forecast)
Ergot	(claviceps OR claviceps purpurea OR ergot OR sphacelia segetum OR sclerotium clavus OR sphaeria purpurea) AND wheat AND (model OR simulation OR prediction OR forecast)
Barley yellow dwarf virus	barley yellow dwarf virus AND wheat AND (model OR simulation OR prediction OR forecast)
Agriotes spp	(agriotes OR wireworm*) AND wheat AND (model OR simulation OR prediction OR forecast)
Russian wheat aphid	(diuraphis noxia OR russian wheat aphid) AND wheat AND (model OR simulation OR prediction OR forecast)
cereal leaf beetle	(oulema melanopus OR cereal leaf beetle) AND wheat AND (model OR simulation OR prediction OR forecast)

The working method

The working method recommended for Mopest was applied (see paragraph 1.1, sub-section “The working method”):

1. perform the literature search in CAB Abstracts database (or any chosen database);
2. review each paper found on the basis of information in the title and abstract: if the paper meets the eligibility criteria, it is considered of potential interest for Mopest; otherwise, it is discarded (note: term ‘potential’ means that the papers could be discarded or used as a related reference of another entry, based on the information drawn from analysing the full text, as described in step 4 below);
3. retrieve the full papers considered of potential interest for Mopest;

4. review the full paper: if the paper meets the eligibility criteria, it is considered of interest for Mopest; otherwise, it is discarded or used as related reference of another entry;
5. select further papers from the “references” section of the papers found; these papers are then managed starting from step 3.

Eligibility criteria for selecting items to be included in Mopest’s review

After the literature was searched, the records were qualitatively assessed on the basis of the information available from the abstract. If the eligibility criteria (see paragraph 1.2) were not met, the record was considered unsuitable for the Mopest inventory. The most common reasons for rejecting a paper were the following:

1. the paper does not concern pest modelling;
2. the paper does not concern the kind of models of interest, i.e., weather- or climate-driven models, or models considering plant growth or development;
3. the paper concerns pest modelling, but the model is not described in a transparent manner (e.g., there are no equations), or it refers to pests or plants other than the one of interest, or it shows other mismatches with the eligibility criteria.

Annex 2

Use of the Mopest inventory - Example of a record

PAGE 1

Title
Appearance of Puccinia recondita f.sp. tritici on winter wheat: a simulation model

Original Title
Appearance of Puccinia recondita f.sp. tritici on winter wheat: a simulation model

Publication Type (Selected)
Journal article

ID Main reference
1

Author(s)
Rossi V, Racca P, Pancaldi D, Alberti I

Address
Via E. Parmense 84

Postal Code
29100

City
Piacenza

Country
IT

Phone

Fax

Email

Online Contact

Institution
Istituto di Entomologia e Patologia vegetale, Università Cattolica S. Cuore

Administrator Area

Hours Service

Contact Instruction

Year
1996

Publisher Name
Blackwell Publishing

Publisher Country
GB

Publisher Location
Oxford

Availability
subscription fees or article purchase on line

Source (Bibliographic Information)
Rossi V, Racca P, Pancaldi D, Alberti I (1996) Appearance of Puccinia recondita f.sp. tritici on winter wheat: a simulation model. EPPO Bulletin 26: 555 - 566

ISBN

Online ISSN
1365-2338

Print ISSN
0250-8052

Other Bibliographic Information

Name of PDF file
RUSTPRI_Paper.pdf

Link to Publisher www
http://www3.interscience.wiley.com/user/accessdenied?ID=119212575&Act=2138&Code=4719&Page=/cgi-bin/fulltext/119212575/PDFSTART

Link to EFSA Library

Related reference

ID related reference 2
2
Authors 2
Year 2
Title 2
Other Bibliographic Information 2
Name of PDF file 2
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ID related reference 3
3
Authors 3
Year 3
Title 3
Other Bibliographic Information 3
Name of PDF file 3
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ID related reference 4
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Authors 4
Year 4
Title 4
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Link to EFSA Library 4

ID related reference 5
5
Authors 5
Year 5
Title 5
Other Bibliographic Information 5
Name of PDF file 5
Link to Publisher www 5
Link to EFSA Library 5

Contact person

Last Name
First Name
Institution
Department Faculty
Address
Postal Code
City
Country
Phone
Email
Fax
Online Contact
Administrator Area
Hours Service
Contact Instruction

Chronology

Profile creation
Profile modification

Model subject

Full Name of the Model
Rust Primary Infection

Acronym
RUSTPRI

Version number

Pests

Insects
Mites
Nematodes
Fungi / chromista 1
Bacteria
Phytoplasmas
Viruses

Specify Pests (Selected)
Puccinia recondita f. sp. tritici

Other

Plants

Plants (Selected)
Triticum aestivum

PAGE 2

Model acronym
RUSTPRI

Abstract

From the paper
A simulation model was developed for the appearance of leaf rust (Puccinia recondita f.sp. tritici) on winter wheat. The model was based on the uredospore cycle. Relationships between weather, host and infection processes (such as uredospore germination, germ-tube penetration, length of latent period, uredia eruption) were transformed into model parameters by curve fitting, corrections and empirical assumptions. The model was validated by a backward method: model outputs were compared with actual data collected at eight sites in northern Italy over 4 years. The model gave a good simulation of the establishment of primary infections of leaf rust: an agreement between disease appearance in the field and model outputs was found in 93% of the 28 cases in which rust appeared. Air temperature and leaf wetness were the limiting factors for infection establishment. A prevalent (96% of cases) association between rain and infection showed that uredospores causing infections were washed onto the ground by rainfall.
Additional (from CAB or Mopest)

Language

English Yes	German	French

Language(s) (Selected)

Subject category(ies)

Crop Science	Soil Science	Environmental Science	Land Use Studies	Crop Protection 1	Pest Science 1
Forestry	Farming Systems	Food Science	Agricultural economics	Other	Other (text)

Aggregation level

Pest Organism	Pest Population 1	Pest Meta-Population	Other	Other
Host Organ	Host Plant	Host Crop 1	Host Cropping System	
Host Farm	Host Ecosystem	Host Landscape	Host Other	Host Other

Geographic coverage

Applicable
No
Level
World
Continents
Coverage Countries (Selected)
Country Subdivisions (Selected)

Temporal coverage

Applicable
Yes
Coverage
1990-1993 (validation)

Technical specifications

Executable Existence No			
Executable Availability No	Download Link (URL)		
Download Made	Link where download is stored		
Downloaded Version	Update	Date Last Download	
Hardware Required			
Operating System			
Other Software Requirements	Software Required		
Programming Language			
Source Code Available	Link to PDF file		
User's Guide Available	Link to PDF file		
Technical Reference			
User Contract Mandatory			
Remarks/Additional information			
Access or use Constraints			
Contact Name			
Contact Institution	Contact Administrator Area		
Contact Address	Contact Postal Code	Contact City	Contact Country
Contact Phone	Contact Fax		
Contact Email	Contact Online Contact		
Contact Hours Service	Contact Contact Instruction		

Type of model

1st selection (Selected)
analytical mechanistic

Scientific model specifications

Flow Diagram (link to PDF file)
RUSTPRI_FlowDiagram.pdf
Mathematical Information
Rephrased from page 556 to 558: The model simulates the uredospore cycle. The number of rust infections established on a day is calculated as the product between the number of uredospore deposited on leaves and the infection efficiency of uredospores. The infection efficiency is a function of the uredospores germination rate and the germ tubes penetration rate. These rates vary in response to temperature and leaf wetness duration. The model calculates also the number of uredia that erupted on leaves in each day, after the accomplishment of the latent period, which depends on temperature.
Assumption(s)
Model Uncertainty

PAGE 3

Model acronym
RUSTPRI

Input data concerning weather

Measured Variables (Selected)
Relative humidity; Rain; Air temperature

Measurement Time (Selected)
Daily

Sensor Type(s)

Sensor Location (Selected)

Calculated Variables (Selected)
Leaf Wetness Duration

Other Calculated Variables

Measurement Time (Selected)
Daily

Input temporal extent
Wheat growing season.

Input data concerning pest(s)

Measured Variable(s) (Selected)

Measurement Time (Selected)

Measured Parameters (Selected)

Measurement method(s)

Documentation (link to PDF file)

Calculated variables

Measurement Time (Selected)

Input temporal extent

Input data concerning crop(s)

Measured Variable(s) (Selected)

Measurement Time (Selected)

Measured Parameter(s) (Selected)

Measurement method(s)

Documentation (Link to PDF file)

Calculated Variables
Leaf Area Index calculated according to equation at page 558: LAI = 1.4579 + 0.1987 * DAY - 0.0043 * DAY^2 + 0.21 * 10^-4 * DAY^3 where: DAY = 1 on the 1st of April.

Measurement Time (Selected)
Daily

Input temporal extent
Wheat growing season.

Output

Output(s) description
The model determines the day on which rust infection can be established, the proportion of uredospores that can infect the leaves, and the time in which rust monitoring may be intensified.

Measurement Time (Selected)
Daily

Output temporal extent
Wheat growing season.

Pests	Pest Output (Selected)
1	Disease Onset
Losses	Losses Output (Selected)

Model evaluation (1)

Validation	#n	Method Used (Selected)
1	1	
Verification	#n	Method Used (Selected)

Description
From page 558, "Model validation" section: The model was validated by a backward method: starting from the day in which leaf-rust symptoms were observed in the field for the first time, the range of days in which all uredia of the same infection cycle erupted was determined; then the corresponding latent periods were calculated and the day when infection could have been established was found. Finally, the infection efficiency in each day was calculated and the day when the maximum efficiency was recorded was considered as the day in which infection had established.

Results (from the paper)
From the abstract: The model gave a good simulation of the establishment of primary infections of leaf rust: an agreement between disease appearance in the field and model outputs was found in 93% of the 28 cases in which rust appeared.

Documentation

Results (additional)

Model evaluation (2)

Sensitivity Analysis	#n	Method Used (Selected)
Uncertainty Analysis	#n	Method Used (Selected)
Calibration	#n	Method Used (Selected)

Description

Results (from the paper)

Documentation (link to PDF file)

Results (additional)

PAGE 4

Model acronym
RUSTPRI

Research	Education	Simulation	Prediction
1		1	

Decision Support	Warning	Precision Farming	Expert System
1			

Database	Main Other	if other

Current Limitation(s)

Future direction(s)
From page 563, bottom of the page: This simulation model for leaf-rust appearence is a sound base for future development of an advisory system.

Suggestion(s) for proper use

NOTES

Note(s)