TESS
Transactional Environmental Support System

SEVENTH FRAMEWORK PROGRAMME

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D4.1 Database of models that relate species and incomes to land-use

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Introduction

Transactional Environmental Support System (TESS) is an RTD project which, among other expected results, must collect and analyse the existing modelling and data sources to enable generation of a conceptual platform for decision support software solutions. Kenward *et al.* (2010) found that the number of decisions made at EU level as Directives, and as regulations by policymakers at national and sub-national levels, are necessarily relatively few compared to the decisions made by local stakeholders in the use of land, water and species, simply because local stakeholders are far more abundant. Their report showed high importance of local authorities and private managers or users affecting biodiversity. Hence, the database of models was designed for such local stakeholders.

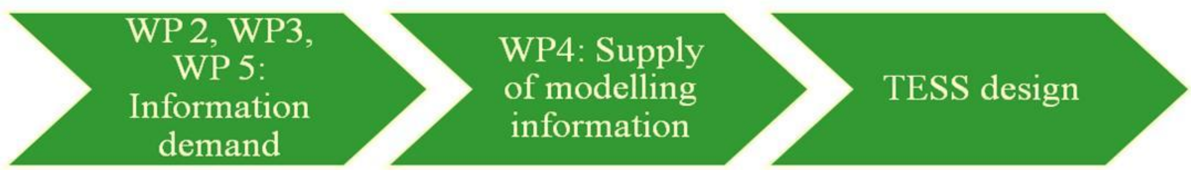

Fig 1 Information flow through work package 4 of the TESS project.

The database of models was generated and analysed according to the information demand from work packages 2, 3 and 5 of the TESS project (Fig 1). The database and its analyse is targeted for work package 6 and further activities which design the TESS. Fig 1 Information flow through work package 4 of the TESS project.

Methodology

Scoping: determination of the work package targets and boundaries.

Need analysis. The exact scoping of the work package applied the analysis of information flows delivered from work packages 2 (central policy environment) and 3 (local environmental information). Case studies in local communities (work package 5) provided more specific information on needs for environmental decision support.

In the preliminary survey for 9 states, Hodder et al. (2009) found that managers have good knowledge of ecosystem supporting services such as maintenance of soil quality, and ecosystem regulation services such as avoidance of hazards, while they **require information on wild species and habitats** (Fig 2). Local administrations (Tier 1 and Tier 2) also required such information and were relatively more interested in environmental hazards. On this basis, although all ecosystem health aspects were considered, special efforts of this work package targeted on wildlife as well as natural and semi-natural habitats.

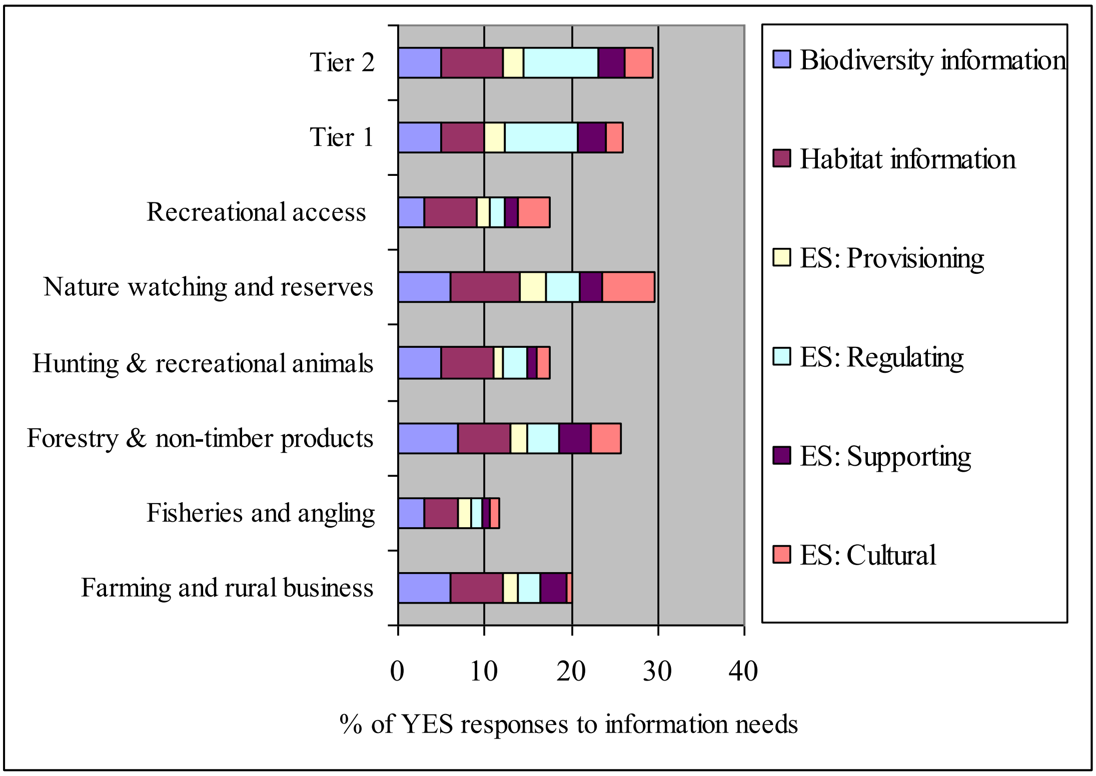

Fig 2. The types of environmental information needed by the different categories of stakeholders and representatives of local government (Tiers 1 and 2), categorized by biodiversity information and ecosystem services (ES). The results are combined for all case studies of TESS project (Hodder et al., 2009).

In terms of ecosystem services, commonly required information included that relating to **water, wild meat and fish, and fibre (e.g. timber), disaster management (e.g. floods), and capacity for tourism and recreation**. Less commonly required was information on wild plants and fungi, cultivated crops, soils and impacts of tourism and recreation. However, to achieve completeness of the database, these aspects were still integrated to the database of models.

In the randomised survey across a majority of European states, Kenward et al. (2010) found that there was very great variation in the availability of necessary information (Fig 3) to the most local (Tier 1) administrations.

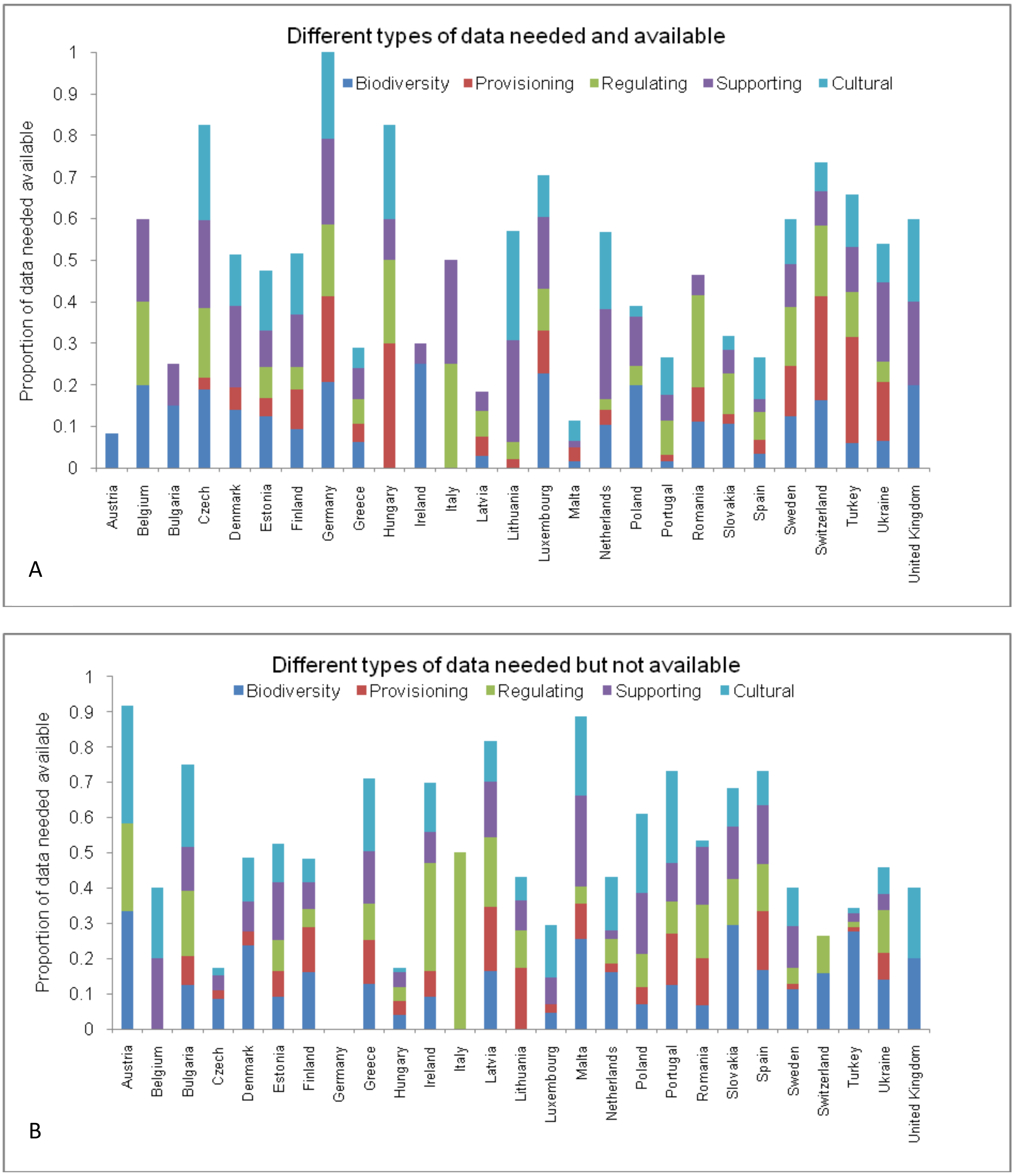

Fig 3. The proportions of different types of data needed by local administrations to make environmental decisions (Kenward *et al*., 2010). A Data which were available. B Data which were not available.

The Czech Republic, Germany and Hungary stood out in having most of their needs met, whereas Austria, Bulgaria, Latvia and Malta were being especially poorly served. Information requirement on ecosystems for provisioning (crops, medical, biofuels), regulating (flood/fire/disease hazards) and supporting (water/air/ soil quality) services was especially variable, whereas **information on cultural services (amenity, recreation, tourism) was generally in high demand** (except for Italy, which was most interested in natural hazards). Information on **biodiversity** (protected and harmful species and habitat maps) was also generally in high demand, except for Italy and Lithuania.

Kenward *et al.* (2010) also indicated that local land-managers weakly use Internet while local authorities use GIS well. Their report also showed that local authorities in many Western European countries as well as in Estonia have high digital enablement. However, they discuss if the digital decision support should be focused to these countries or rather to countries with good biodiversity status. Thus, this project has not focussd on any particular group of member states. Hodder et al. (2009) reported that of various environmental issues local governments identified socio-environmental issues (Fig 4). Hence, while compiling the database, conceptually broad environmental models, containing economic terms and socio-cultural dimension, were a particular search target.

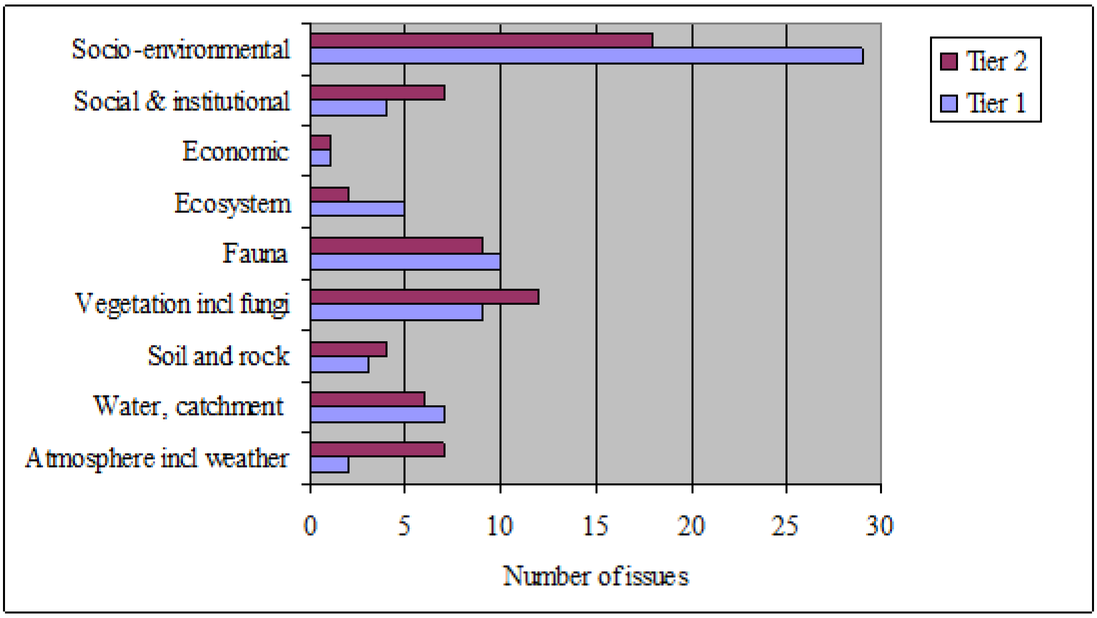

Fig 4. Environmental issues identified by representatives of local government in the partner countries sorted into subject categories compatible with categories of environmental models used to analyse and predict the impacts of decisions in TESS WP4 (Hodder et al., 2009). Each issue could be assigned to more than one category.

Conceptual approach. Among several concepts of environmental management, the concept of natural capital (e.g. Hawken et al., 1999) sees the world's economy as being within the larger economy of natural resources and ecosystem services that sustain us. Only through recognizing this essential relationship with the earth's valuable resources can businesses, and the people they support, continue to exist.

In practical implementation of natural capitalism, the hardest constraint seems the question of ownerships and hence responsibilities in the management of natural capital. As far as the bulk of natural capital – biosphere and its services – where ownership remains common, market forces fail to effectively regulate its sustainable management.

In a simplified scheme, private and common issues project to small-scale and large-scale issues. Market failure can be explained as the failure of local investments to generate local benefits. For instance, a company which invests (e.g. through forestry) in the production of atmospheric oxygen does not benefit for that service from ordinary market forces. At the same time, market forces usually fail to hinder a company in the introduction of alien species. However, large-scale drivers create also small-scale consequences (Fig. 5).

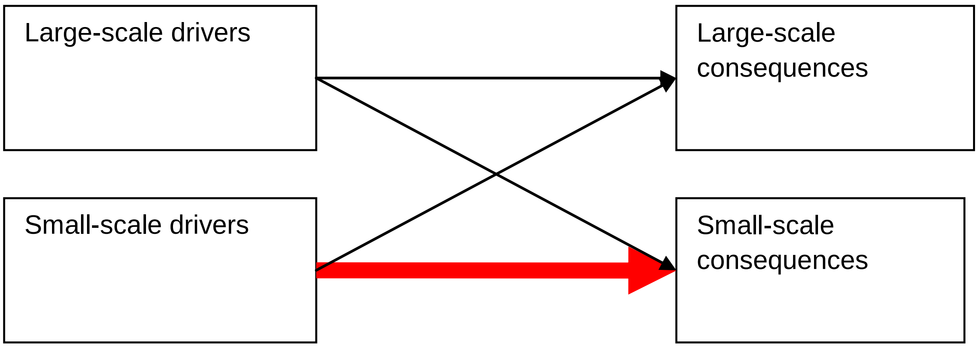

Fig 5 Interactions between large-scale and small-scale issues limit the efficiency of local actions (red arrow)

However, many field-scale investments to natural capital still give significant field-scale benefits. For instance, fertilization of soil is a typical investment to natural capital which gives returns to the field manager. Thus, **this database was targeted on such activities where local ecosystem management decisions bring via improved ecosystem services direct benefits to the manager**.

Of the variety of ecosystem services, several ones, such as genetic resources and primary production, prove purely global. However, several services, such as provision of materials and pollination, have also great local significance (Fig 6). Hence, **this database was targeted on the management of ecosystem services which generate local benefits**. **Thus, we focused on promoting health of ecosystems**.

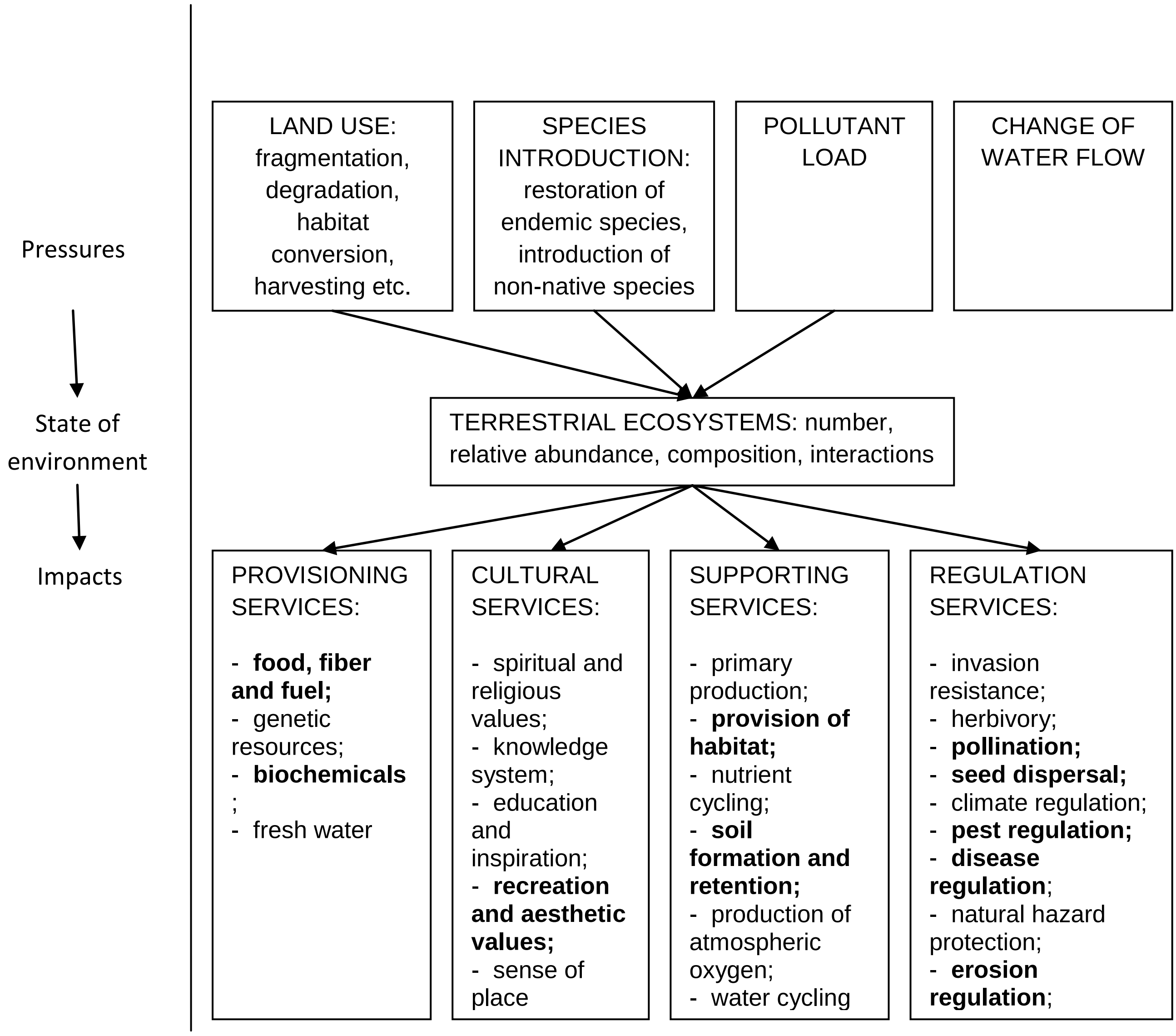

Fig 6. State of ecosystems in DPSIR network. Bold font indicates services which generate mostly local effects, conforming thus to local management

Outside the "tragedy of commons', several other obstacles hinder sustainable management of ecosystem services. Short-term (tactic) interests often compromise long-term (strategic) interests. Ecosystem health is usually a long-term issue, requiring strategic planning. Due to natural buffers, the consequences of different management scenarios to ecosystem health tend to lag. Managers might, thus, need tools to assess ecosystem health issues. We identified three most significant economic areas where sustainable local ecosystem management might bring direct revenues: farm-scale agriculture, estate-scale timber production, and on-site management of recreational objects (Table 1). The aim of the database was to provide information tools for these management challenges for the entire EU. **Thus, we focussed our search on models to address productive ecosystem services and revenue-bringing cultural services.**

Table 1. Interest areas of TESS WP4 database

Economic area	Scale	Target groups	Output	Major factors
Agriculture	Farm	Farmers	Sustainable crop and fodder production issues: **soil maintenance, fertility, health**. Field immunity against pests.	Erosion. Drainage. Irrigation. Pollinators. Chemicals. Cultivation structure. Buffer strips. GMOs. Biocontrol. Weather and climate.
Forestry: timber production	Estate	Private forest owners and managers	Sustainable timber production. **Forest health**	Factors of wood diseases. Biocontrol agents. Drainage. Irrigation. Harvesting options. Storm and fire resistance. Climate change
Nature recreation: hunting, fishing, birdwatching, hiking, walking, picking, riding	Recreational site	On-site tourism operators, local land-owners	**Maintenance and improvement of the leisure object**: production of games in a forest, production of fish in a small lake, number of valuable birds to watch, attractiveness of the object, availability of forest fruits	Habitat requirements, Effects of pollutants, Hunting and fishing rate, tramping, garbage, number of people, behaviour of people. Climate change.

Analysing needs and possibilities of decision support for local ecosystem management.

A literature study was conducted, resulting with a research paper (Piirimäe, 2011). The study concluded that conventional types of EDSSs, which work as simulation or optimization models, continue to have great potential. However, arithmetic and data processing addresses only a small fraction of the challenges in decision-making. Firstly, assessment of management options requires also qualitative reasoning. Secondly, decision-making consists of several consequent steps which require different mental processes and have design implications for a comprehensive ecosystem management EDSS. Fortunately, in recent years, decision support approaches have greatly diversified. In parallel, new findings in human behaviour and psychology as well as informatics enable more systematic mapping of future needs for design and application of EDSSs.

A review of recent knowledge drew the following major conclusions:

1) As most management models ignore social factors (e.g. impact on reputation), EDSSs might mistakenly recommend environmentally harmful behaviour. Therefore, a totally comprehensive EDDS should include reputation-related consequences in its economic module.

2) In case of long-term or large-scale problems, forecasting capabilities may be insufficient that decisions result in sustainability. Thus, only local and short-term

environmental problems serve as promising subjects to be solved currently by informational tools such as EDSSs. It is particularly important to adapt EDSSs with local social contracts.

3) As the human mind possesses powerful capacities to make decisions independently, the potential of a computer is limited to data processing and analysis, sequential arithmetic and deductive reasoning.

4) As humans do not decide consciously, EDSS can influence decision-making only by stimulating intuitive reasoning and creativity (Table 2).

Table 2. Hypothetically successful EDSS design strategies resulting from the studies of human intuitive reasoning

Intuitive mechanism	Subsequent implications for EDSS
Learning	Good presentation of internal knowledge, high quality syntax, mnemonic names of variables, possibility to add comments in model text
Social domain	Integration with social issues, transformation of environmental questions to social questions
Imitation	Demonstration of best practice examples
Social contracts	Focus on legislative and moral aspects
Precaution	Focus on risks and hazards
Creativity	Relaxing, creative virtual environments

5) EDSS could provide variable types of assistance in various decision steps (Fig 7). Issue definition and criteria setting require articulation of the problem by universal decision frameworks and the Socratic method. Option generation needs creativity support by the provision of various creative environments. In the option assessment step, computers can support by arithmetic computations, deductive reasoning and stimulating intuition.

6) Due to conceptual and technical inconsistencies, pipelining of all simulation tools to a universal environmental supermodel is impossible now and will be extremely challenging to achieve for the future. However, a toolbox approach might organise various independent tools in the issue definition phase, and with careful planning can start a process of integration.

7) Decision quality can improve by the involvement of experts of different knowledge domains, reasoning types, creativity types, decision steps etc. This further involvement of social control appears to be another promising perspective.

Compared to the preliminary project concept which aimed to integrate various simulation tools, this study suggests a much broader approach, in which simulation models might be only one component among various decision support tools. More specifically, simulation models fall mostly under ’arithmetic computations’ which, together with other types of software tools, aid human reasoning. This, in turn, forms only a part of the sequence of steps in a decision-making process (Fig 7. Potential functions of computer to assist environmental management throughout decision steps). Hence, an integrated decision support system might functionally partiton to various tools aiding specific decision steps. The metadatabase approach of WP 4 needed to take account of this overarching consideration.

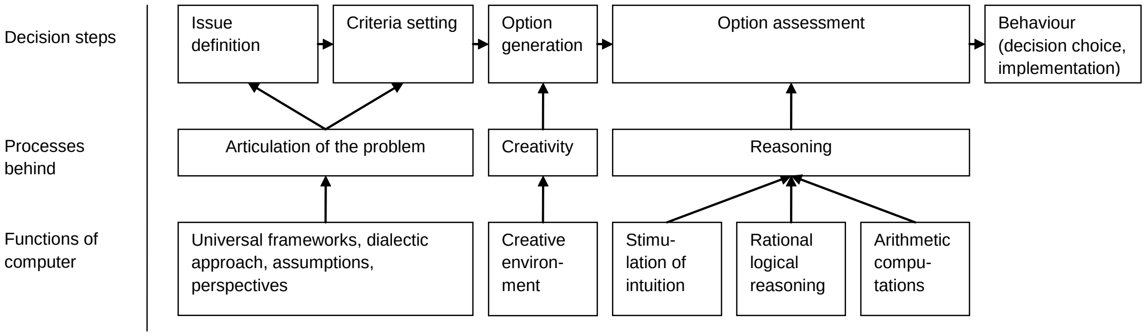

Fig 7. Potential functions of computer to assist environmental management throughout decision steps

Creation of the structure of the database of models.

No single model can address the needs of all local ecosystem management situations, and attempts to build such models will likely suffer from over-generality, scale mismatch issues, or endless additions to address new data and questions (Derry 1998). We thus omitted an illusory idea of creating a general global computation algorithm for ecosystem health management. Managers, instead, need a general and flexible framework that answers the questions being asked at the right scale and in a timely and cost-efficient fashion, while still integrating the three dimensions (social, economic, and ecological) that shape managed ecosystems. **We therefore designed a metamodel, consisting of a framework of toolkits which build on existing and readily adaptable modelling tools that have been developed and applied to previous research and planning initiatives**.

The highest level of hierarchical structure in the metamodel tops is Local Ecosystem Health Management Decision Support Framework (LEDS, Fig 8). This framework could be internal and not obvious functionally to target groups, but could organize a set of toolkits, each of which is a separate product for a distinct target group, distinct economic area and corresponding type of managed ecosystem. Although communicated independently, the toolkits in the framework would interrelate strongly due to many overlapping features.

Similarly with the general framework, none of the toolkits would aim to propose a universal computational model to work everywhere in the EU. Instead, the main purpose of each toolkit could be to outline the process of identifying questions, finding the tools and information to answer them, and then ensuring that the interacting suite of domain specific tools informs the global objectives of the planning process. Instead of answering questions, the toolkits could tend to raise questions, highlight problems, and propose tools for the supply of information. The toolkits could also where appropriate stress the need for collaborative analysis involving the right people for modelling social effects (Box 1).

Box 1. Main abilities of each toolkit

A Analytical abilities

1. Assistance in system definition, including system type and boundaries. A management system might be (a) function-oriented (e.g. provision of timber), (b) region-oriented (e.g. management of a certain estate or a certain farm), (c) agreement-oriented (e.g. relations with customers, contractors, authorities etc.).
2. Assistance in definition of information demand, including identification of internal and external drivers for the demand
3. Assistance in defining system scale, including spatial and temporal scale
4. Assistance in spatial specification including ecoregion and climate zone
5. Assistance in question definition. Question types comprise strategic planning, capital investments, design and development, communication and marketing, operational management.
6. Assistance in definition of the aspiration of manager: conservation of status quo, continuous improvement, aggressive change etc.
7. Assistance in the definition of level of control, and degree of freedom in decision making.
8. Assistance in locating decision step which might be either issue definition, criteria setting, option generation, option assessment, or final decision.
9. Finding proper decision-making tools. Depending on the aim of a manager, a suitable tool might be cost-benefit analysis, cost-effective analysis, a checklist, an optimization model etc.
10. Finding proper model(s) for data obtaining and processing as well as presenting information. These models comprise allocation models, mass balance models, material balances, dispersion models, dose-response models, evaluation models, fate models, ecological models, normalization models, uncertainty analysis, scenario development, backcasting etc.
11. Combination, coordination, organization, integration, interlinking and synthesis of models. Each toolbox would contain relational databases, integrating several formalized models.
12. Assistance in involvement of experts and stakeholders to management and modelling

B Holistic abilities

13. Assistance in context definition including sensitivity of the issue, culture of stakeholders etc.
14. Ideation (idea generation): provocations, associative stimulations, confrontations (forced combinations), systematic ideations
15. Thematic query
16. Advanced web search
17. Other information

Section 4.1.2 proposed, among other things, to structure the models according to decision steps. However, considering the project scope, more decisive structural criteria emerged from the analysis. First, architecture of the database was solved as a metamodel, organizing the application of various software tools (Fig 8). Second, these software tools were grouped to three toolkits: Field Health Toolkit, Forest Health Toolkit, and Recreational Site Management Toolkit. Various tools in these toolkits could be linked by pipelining with special software platforms such as OpenMI (Moore & Tindall, 2005) and LIANA (Hofman, 2005), while incommensurable tools could be linked holistically, at least partly in a user-mediated way.

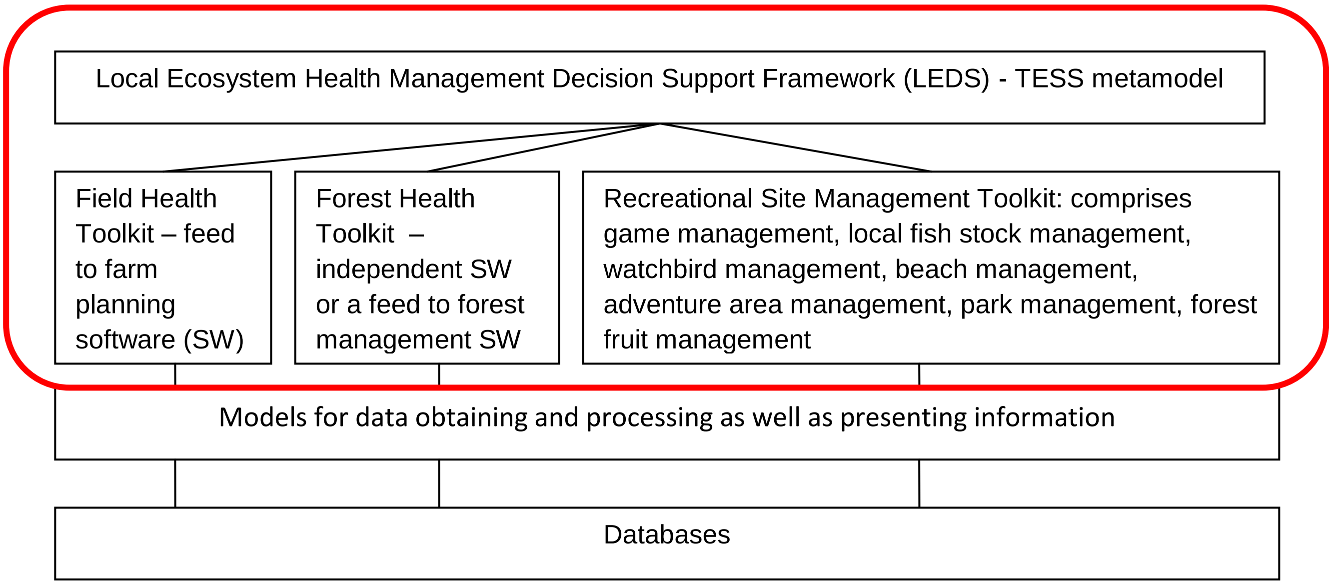

Fig 8. Structure of TESS metamodel. Red outline indicates borders used in WP4

Hence, the fundamental architecture of the database considered the need to organize and integrate various decision support tools into three toolkits. At the same time, functional aspects of the decision support required consideration of how each type of each tool would aid a particular decision step. In this context, pre-simulation steps in a decision-making sequence (section 4.1.2) appear relatively domain-general, hence, rather unsuitable for our domain-specific environmental management database. We concluded that pre-simulative tools should be integrated to each final toolkit but largely excluded from the metadatabase.

The question of **system complexity** is one of the major challenges of the TESS project. Addressing numerous environmental problems all over the EU as well as integrating different model approaches requires rather complex thinking. In the same time, the target groups – local managers – will include persons without special training or education in environmental issues and modelling. In principle, they should nevertheless be able to work with a given toolbox while understanding calculations and other processes in it.

For solving the question of system complexity, we adopted the model of hierarchical complexity (MHC, Commons et al. 1998) which quantifies the order of hierarchical complexity of a task based on mathematical principles of how the information is organized. MHC defines at least 14 universal discrete stages of complexity which might also define human cognitive development, regardless of cultural context.

The toolkits should generally not operate above a formal level which corresponds to the order 10 in MHC (Table 3). Order 10 includes rational and analytical processes using empirical or logical evidence. Formal logic, however, remains linear and one-dimensional. Order 10 allows for relationships between variables, hence correct scientific solutions. More complex models, such as multivariate systems and fuzzy relationships, should either be avoided or require good explanatory support from the system (e.g. for uncertainty).

Table 3. Framework of complexity in TESS project

Cognitive framework (order, Commons)	Modelling framework (types of model)	Application in TESS project
10 Formal	Formalised models	Operation of toolkits and ecological models within these
11 Systematic	Metamodels	Architecture of WP4 metamodel and its toolkits – organises the application of ecological models
12 Metasystematic	Integral frameworks	TESS project implementation

While the toolkits would operate at formal level 10, their architecture and the metamodel would work at systematic level (11) which includes multivariate matrices and contexts. As far as the toolkits operate in order 10, our WP4 metamodel itself does not need to operate higher than order 11. It is worth noting that the TESS project itself, organizing the metamodel, operates at the 12th level, which is metasystematic: constructing supersystems, multi-systems and metasystems out of disparate systems.

Creation of the classification structure for models.

Which criteria classify environmental decision support models better? Apart from visualizations and conceptual models, research communities differentiate mathematical models predominantly by temporal and spatial complexity, geographical limitations, decision type, environmental theme, computational and technological approach (e.g. Jörgensen & Bendoricchio, 2001). To select the most useful of these, we needed model classification metacriteria, i.e. criteria for classification criteria. Depending on the need, our model classification might be according to the labour or expertise required by models, which wuld relate to whether they serve research, educational, management or other needs. We needed to classify models to generate a conceptual platform for decision support software. Hence, we chose classification criteria which functionally facilitate the design of decision support systems, for which complexity is an important consideration.

Stage 1. Organisation of knowledge according to vertical complexity. After finalising the general architecture of the metamodel, the collection, organization and integration of decision tools required further classification. Aiming towards integrated toolkits, we classified the tools according to ease of integration, i.e. vertical complexity. The resulting classes were: 'conceptual frameworks'; 'metamodels (integration concepts)' – including toolkits; 'models' – including higher rating 'computer programmes' as software tools and lower rating 'raw models' such as regression formulae; 'variables'; and 'data' (Fig 9).

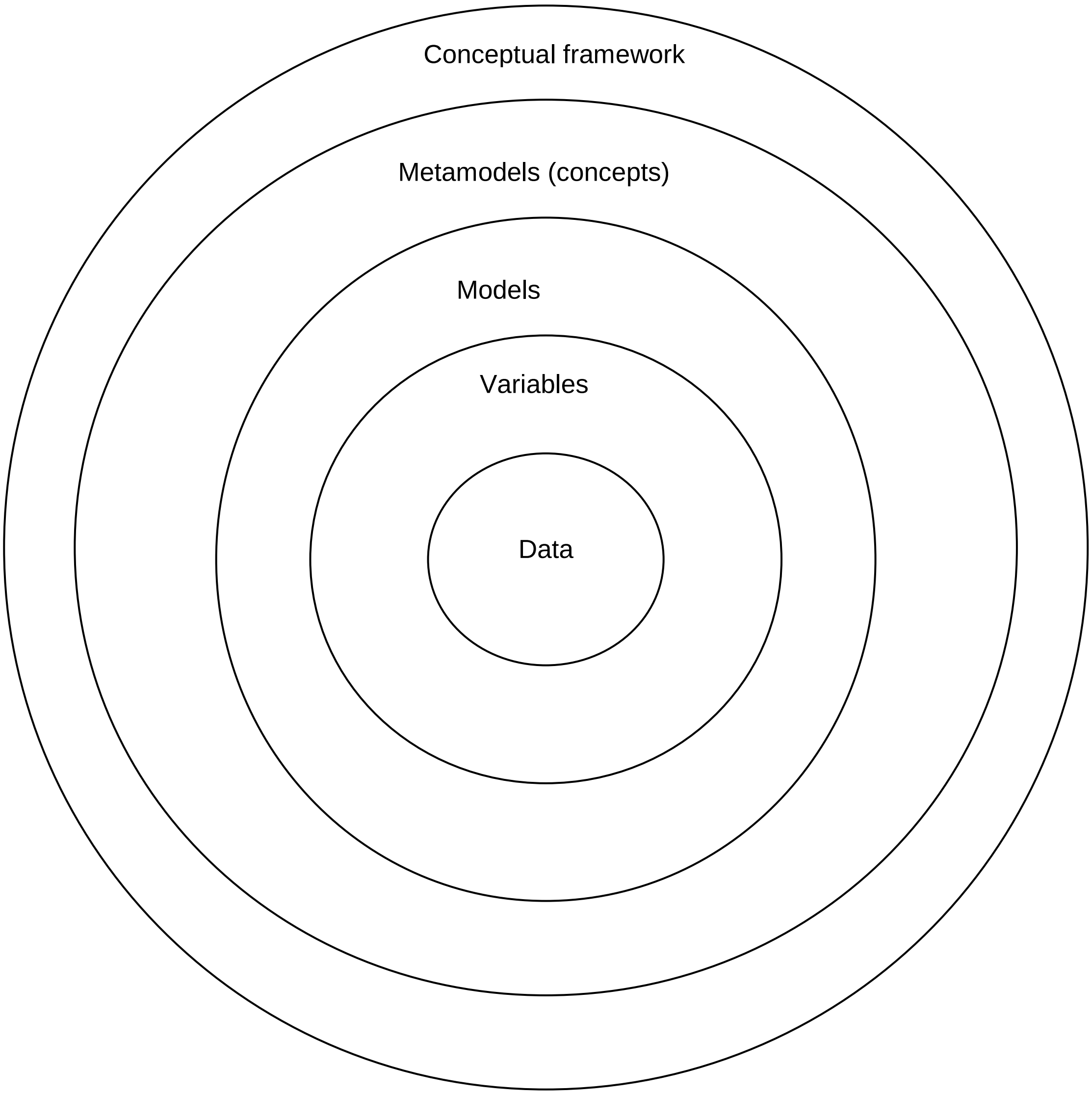

Fig 9. Holarchic organisation of knowledge in local ecosystem management

Models serve as building blocks of toolkits. In WP4, we aimed to find, classify and organize decision support models for the services of toolkits. The existing useful models fall under several category of complexity. Advanced models work as user-friendly smart **computer programmes**, able to automatically calculate outputs from input data. Our task is to find conceptual solutions for integrating these programmes to toolkits. For instance, SILVA is an individual tree-oriented management software model. Our challenge is to integrate it with statistical forest management models. We should also consider that instead of providing solutions for concrete management situations, the main benefit of management models might be training the user to make better decisions (Walker, 2002).

Some environmental management issues nowadays lack decision support programmes. These cases require searching for research results such as published regression formulae and information on significant processes determining output values. Typically, these **raw models** have no names. Usually they need programming to integrate into toolkits and computer models. Our task is to set these programming strategies. For instance, if there were a lack of user-friendly models for game management, an extensive literature review might reveal conceptual and quantitative models determining population density of and income from various game species. We could then develop strategies to integrate these raw game population models into the relevant toolkit.

Thus the project needs to work in lower levels of complexity in order to feed the designated toolkits. In spite of literature search, some raw models will probably remain missing. Even the **variables** for a required output might be unknown. Such knowledge gaps require mapping. Where models are highly necessary, then we could probably build up the preliminary versions of such raw models ourselves. For instance, population dynamics of brown bears might not yet be modelled. The main factors likely to control the dynamics could emerge as a result of our research, revealing a preliminary raw model.

Finally, in the most extreme cases, crucial **data** might be missing, hindering proper functioning of models. Such situations potentially require us to search for or estimate such parameters, constants or other background data.

Based on the above described context, the handled knowledge falls into categories of vertical complexity, forming a holarchic system (Fig 10). According to Koestler (1967), a holarchic system (hierarchy of holons) consists of holons whereas each holon is both a part and a whole. For instance, models form a holon which is an organization of variables while models themselves could be organized to metamodels, which is one holon higher level of knowledge organization. Such system correlates approximately with Model of Hierarchcial Comlexity (MHC, Commons et al., 1998) and the framework of complexity in WP4.

Stage 2. Organization of models according to commensurability. As concluded above, the classification of models in WP4 assumed a need to integrate commensurable models and databases to generate hybrid supermodels and relational databases. GIS data from different geographic locations should transform and link to a standard pan-European platform (e.g. through INSPIRE). As much as possible and relevant, various regression models need to integrate to bigger units such as Forest 5 (Robinson & Ar, 2003). The vision of such technical integration and pipelining directed our model classification. A group of models which enable such pipelining is defined as commensurable, and should fall into a distinct model cluster in the metadatabase. In contrast, incommensurable models should classify to different clusters, but perhaps be linkable in user-mediated or holistic ways.

Temporal and spatial commensurability. Environmental decision support models might differ according to spatial and temporal criteria. Temporally, model categories comprise static (lumped), steady-state and dynamic models. The latter class, in turn, often splits in short-term (tactical) and long-term (strategic) models. Spatially, models divide between 0D (non-spatial), 1D (linear), 2D (plane), 3D (spatial) models (Figure 10). The subdivisions might include small-scale and large-scale models.

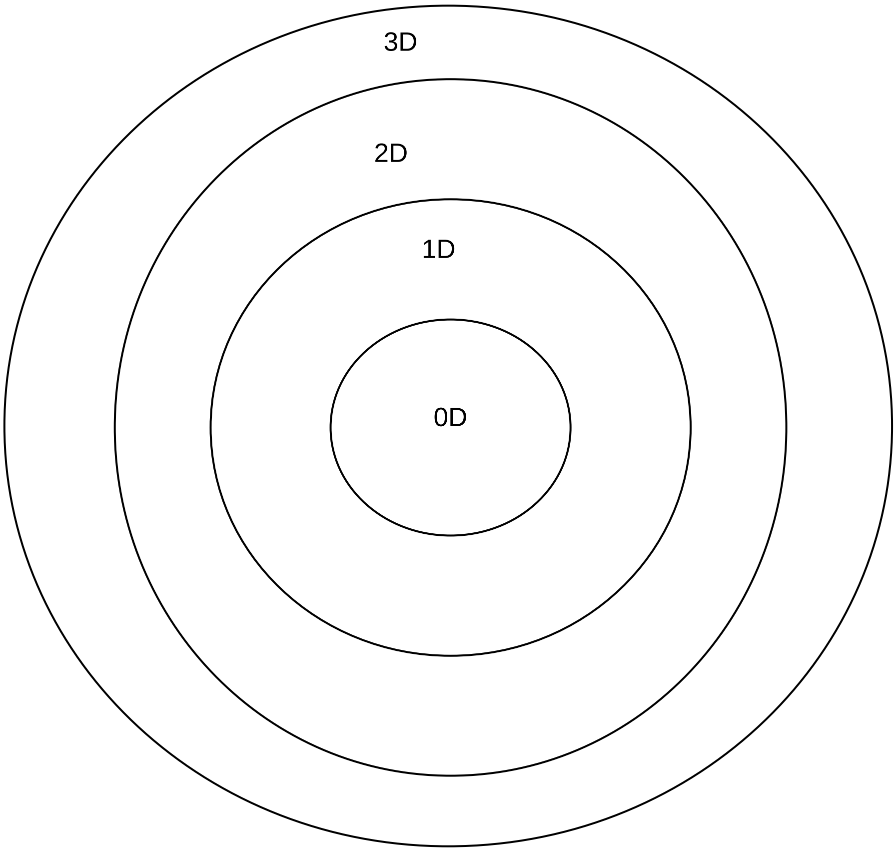

Fig 10. Holarchic relationship between models of different spatial type – all appearing in principle commensurable

A more complicated cluster can involve simpler relations. For instance, a spatial model can involve non-spatial relationships (Fig 10). Hence, a complex spatial model might commensurate with spatially simpler models (including those without a spatial component). The principle of commensurability suggests that the most spatially complex model defines the spatial complexity of the entire cluster and resolution emerges analogously.

The WP4 metamodel excludes large-scale problems and focuses on field-scale issues. We should address the specific aims of only local management issues. Our context excludes spatially scalar classification

Based on graphical technology, spatial models divide between raster models (including cellular automata) and vector models. In principle, these two graphical solutions commensurate but in practice great care is needed to avoid serious loss of information and increase of computational requirements. Often, raster models are used for cellular automation calculations (of relationshipswithin and between neighboring pixels) while vector models relate various shapes. This can make these two graphical approaches seem practically rather incommensurable (falling to two different model clusters). However, this problem can be solved by using vector GIS where possible, and ten using vector-raster conversion at the required scale before calculations. Of course, non-GIS (aspatial) models can feed both vector and raster approaches.

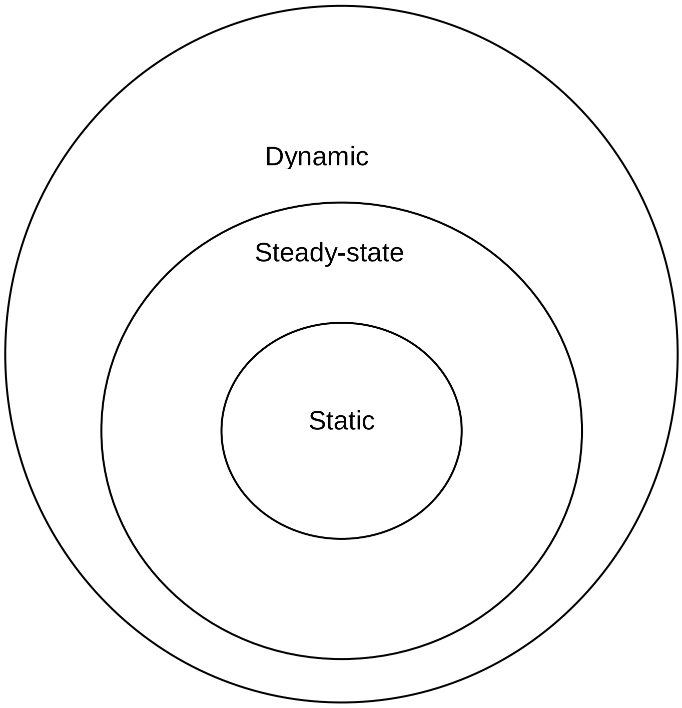

Fig 11. Holarchic relationship between models of different temporal type – all appearing in principle commensurable

Applying holarchic logic, static (lumped), time-independent models can join time-dependent models while steady-state models match within the dynamic cluster. Hence, a dynamic cluster should be able to host both static and steady-state models (Fig 11).

In conclusion, in spatial and temporal terms, vertical complexity of a model cluster could be defined by vertically the most complex model within the cluster. For example, if spatially the most complex model operates in 2D then the entire cluster should operate in 2D. Similarly, the resolution of the cluster should be defined by the resolution of the finest model. For instance, if the finest model in the cluster has a timestep of one day then the resolution of the entire cluster should be also one day.

However, short-term and long-term processes and management issues might differ completely (e.g. Poch et al., 2004). Short-term issues involve optimization of operational management and tactical problems with short feed-back. In contrary, long-term issues involve capital investments, strategic planning, design and development. Long-term models are able to show environmental consequences of management alternatives. Therefore, it might appear necessary to divide the models between short-term and long-term clusters. Some models, however, might apply in both clusters, as for example short term models that iterate effectively for long term predictions.

Computational commensurability. Individual-based (agent-based) models contrast with regression models. In principle, individual-based situations (such as descriptions of state of each individual in a population) are transferable to statistical terms (such as population density). However, the simulation approaches in and management situations of these two model types tend to differ. Regression models aim to reasonably simplify and unify numerous diverse events. One critical assumption of regression models is that individual differences, fluctuations and exceptions are negligible in determining the system outputs.

Hence, regression models work with bulk amounts, counting units of interest. In practice, regression models tend to work well in larger systems with enormous number of individuals or individual events. In contrast, individual-based models assume that individual differences do not average out but generate significant changes to the entire system. Consequently, individual-based models apply different set of approaches such as game theory, Monte Carlo Methods etc. In practice, such models describe well smaller systems where the number of e.g. individual trees or animals is relatively low, and can be especially powerful for forecasting beyond the typical range of data in regression-based models. Such principle differences might suggest splitting all models into regression and individual-based cluster. However, this will depend on the application because, like regression-based models, individual-based models can be used to generate relationships with error terms.

A technical challenge might be pipelining of several high-resolution models which independently run fast enough but together slowly. For instance, a static model with high spatial resolution and a 0D model with high temporal resolution might work independently well but the cluster of high both temporal and spatial resolution might malfunction when pipelined. Solutions could include distributed rather than sequential modelling, reduction of time or space resolution in the best models to synchronise, or user-defined compromises.

In conclusion, with two categories of three classification criteria, the useful models might break up into eight clusters (Table 4). Computationally demanding models might also fall out from each cluster. On the other hand, vector-raster conversion, iteration and simplification of agent-based simulation to regression-like output could provide convergence.

Table 4. Summary table of classification of models into commensurable clusters

Classification criterion	# of classes	Classes
Graphical mapping technology	2	a) vector graphics b) raster graphics
Time horizon	2	a) short-term b) long-term
Simulation technology	2	a) regression b) individual-based
Total	8 model clusters	

Stage 3. Organization of models according to user needs. In a decision support system (DSS), technological classification and clustering of models might differ from the appearance of the system, visible to users. As described above, functionally, **according to user needs**, the TESS WP4 metamodel was split into three toolkits: Field Health Toolkit, Forest Health Toolkit, and Recreational Site Management Toolkit. Each toolkit, in turn, has several tools attributed to it. Each model could work in more than one toolkit and each toolkit could if necessary involve more than one model cluster, perhaps linked holistically (instead of algorithmic links, a toolkit might involve links to menus running different models).

If relevant, the interfaces of toolkits might classify models to **information classes** such as atmospheric class, hydrospheric class, geological class (including soils), sessile class (plants), locomotive class (animals), economic class, sociocultural class etc. However, each toolkit should also clearly indicate all incorporated models.

A questionnaire for collecting the models.

Classification according to the structure and architecture of the metadatabase generated important questions for description, and subsequent search of decision tools. The resulting questionnaire was created as two consecutive web-pages, asking contributors 4+16 questions (http://tess.ttu.ee/). The first page asked the most critical questions while the second page collected additional useful information about each model. The questionnaire was uploaded to Internet and linked to TESS project website. The link was communicated to TESS project partners as well as other potential contributors.

Page 1

Model Name and acronym ....…………….

Web-link ....

Subject:

- Atmosphere including weather (examples: air pollution, noise pollution)
- Water, catchment (examples: hydrological, water pollution)
- Soil and rock (examples: erosion, fertility, compaction)
- Vegetation including fungi (examples: genetics, species, populations, guilds, habitats)
- Fauna (examples: genetics, species, populations, guilds)
- Ecosystem (examples: food chains, natural communities, biotopes)
- Economic (examples: licence fees, markets, fines, taxes, subsidies)
- Social & institutional (examples: legislation, codes of conduct/practice, consultation, conflict resolution, civic activities)
- Socio-environmental (examples: sustainability, climate change)
- Other (please email IST for assistance.)

Ecosystem service management:

- Disease hazards (examples: rabies, malaria, lyme disease, tuberculosis)
- Physical hazards (examples: fires, floods, air quality, water quality, carbon storage)
- Agriculture & apiculture (examples: arable farming, animal husbandry, horticulture, olive production, pollination, biofuels)
- Aquaculture & commercial fishing (examples: salmon farming, ostreiculture)
- Forestry (examples: coppicing, paper, timber, charcoal, cork)
- Wild vegetal products (examples: reeds, fungi, berries, flowers, sap, medical)
- Hunting & angling (examples: falconry, hounds, shooting, game fishing, coarse fishing, spear-fishing)
- Tourism and access-based recreation (examples: rambling, climbing, skiing, boating, camping, golf, dog-walking, horse-riding)
- Amenity areas (examples: parks, gardens, road verges, railway embankments)
- Biodiversity conservation (examples: protection, reserves, re-introduction, alien species)
- Heritage conservation (examples: archeology, buildings, site erosion)
- Other (please email IST for assistance.)

Page 2

Short model description ....

Contact person (name, e-mail) ....

Modelling paradigm

- Simulative prediction
- Optimization process

- Multi-criteria analysis
- Other: please specify ………………….……………………….
  (e.g. dialectic EDSS, creative space, expert system etc.)

If simulative prediction is used, is the approach:

- Rule-based (e.g. qualitative reasoning, rules, rates, environmental ontologies)?
- Regression (statistical, empirical etc.)? deterministic or stochastic outputs?
- Individual/cell-based (agents)? deterministic or stochastic outputs?
- Other

Vertical complexity:

- Published statistical relationship (regression, rate or other formula)
- Software tool, packaging one or more formulae for practical use
- Decision support system, organizing or enabling several modelling tools

Computing platform

- Single computer/PDA
- Internet-linked Servers,
- Distributed Processing (e.g. GRID)

Operating system(s)

- Microsoft (Windows, Silverlight, .net etc)
- Unix, Linux or other Unix-like
- Apple (e.g. Mac OS)
- Other, please specify …

Modelling language(s) …

Graphical mapping technology:

- Raster-GIS (grids, pixels)
- Vector-GIS(polygons, lines, points)
- Non-GIS

Time horizon:

- Short-term
- Long-term
- Not specified

Geographical applicability area

- Universal
- Region-specific: Specify region … …………………………….
- Other

Sectoral application area:

- Research (descriptive)
- Management
- Education and learning
- Other

User-friendliness

- Easy-to-use
- Expert assistance required

User-provided inputs: ....

Computational outputs: ....

Examples of practical application: ……………………………………

Creation of the database of models.

Based on the questionnaire, the database was structured, designed, coded and uploaded to the Internet (http://tess.ttu.ee/, Fig 12). It is a MySql database with web-based administration system written in PHP and working on an Apache2 server. The database enables queries, searches and various arrangements to analyse the models.

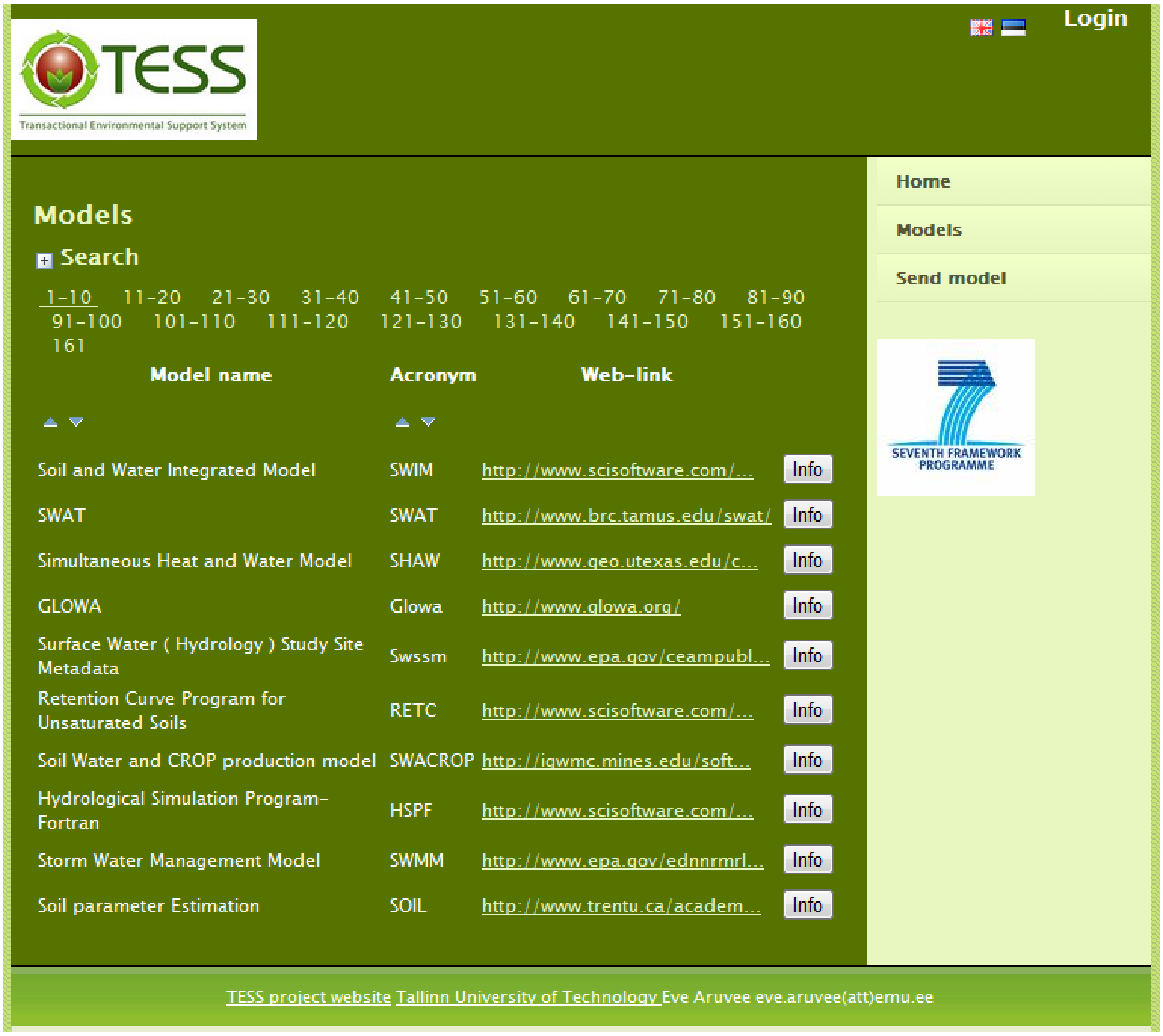

Fig 12. Interface of TESS database of models

Collection of models in the database.

Stage 1. Scanning. The project team and other contributors submitted models to the TESS metadatabase using a web-based submission system (http://tess.ttu.ee). The models were collected mostly from the Internet. Of the existing databases, the most significant sources for this database were ECOBAS (http://ecobas.org), EPA Exposure Assessment Models (http://www.epa.gov/ceampubl), SSG Sources For Environmental Software (http://www.scisoftware.com/html/products.html), NASA Global Change Master Directory (http://gcmd.nasa.gov) and many other environmental management databases. Google search engine (www.google.com) was used to find further models. A network of experts around TESS project partners was used to find additional modelling tools. Scanning revealed more than 2400 environmental management software tools.

Stage 2. Selection. Among the 2400 scanned models, those suitable for this database were selected according to the following criteria: (1) scope and needs of a database focusing on field health, forest health and recreational site management at local scale; (2) quality of models, including update frequency, user-friendliness etc.; (3) availability of models, including on-line availability of metadata.

Stage 3. Delivery. Metadata for each model were filed using the questionnaire and were. collected mostly from web-sites. Fewer data were submitted by external users.

Results

Although the database of models is still expanding, this analysis considers the 165 models which were selected by May 2010. Approximately half of these did not specify all the metadata that was in the questionnaire. As the architecture of the database and some questions in the questionnaire are conceptually relatively complicated, probabilities of controversial interpretation and classification were quite high. For instance, 'vertical complexity', 'modelling paradigm', and 'simulative predictive approach' could be understood differently among various contributors. Moreover, some contributors might lack experience in operating with such concepts. Hence, some of those classifications are still preliminary and require reclassification by the project team after selection of the most useful tools for the toolkits. Until that, the database remains a relatively inconsistent mix of models suitable for the toolkits and models that may not be suitable.

Availability of information about selected models. Half of the software applications in the database are freely downloadable and well described on the Internet. However, small fraction of the models are very poorly described, with only short description of their purpose on the Internet and no information about the mathematical aspects or what input variables the model needs. Most of the models do not have output parameters, which is a very important requirement when creating an EDDS.

Vertical complexity. The web-sites or external contributors omitted to specify vertical complexity of their filed items in 27 of the 165 cases (Fig 13). Of those with specified vertical complexity, as expected, most of the items (113) in the database were reported as 'software tools, packaging one or more formulae for practical use'. However, the database contains also 25 items which initially fitted a description as 'decision support systems, organizing or enabling several modelling tools'. Nevertheless, we later classified most of these 25 models too as just 'software tools, packaging one or more formulae for practical use' due to their very limited integration of basic formulae.

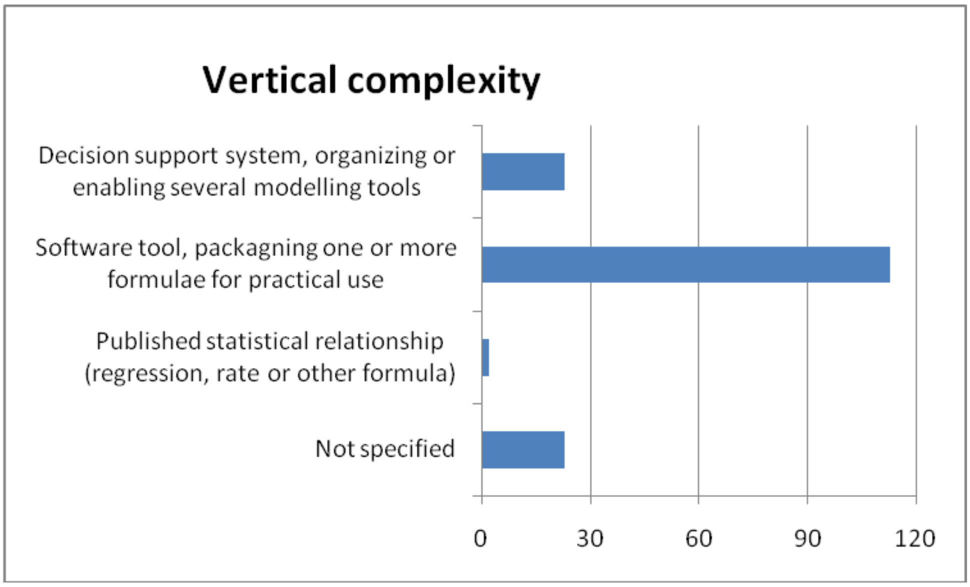

Fig 13. Vertical complexity of models.

Thematic overview. Of submitted tools the database contains 42 items reported as 'forestry' tools, 50 as 'agriculture or apiculture' tools, and 15 targeting to either 'amenity areas' or 'tourism and access-based recreation' (Fig 14).

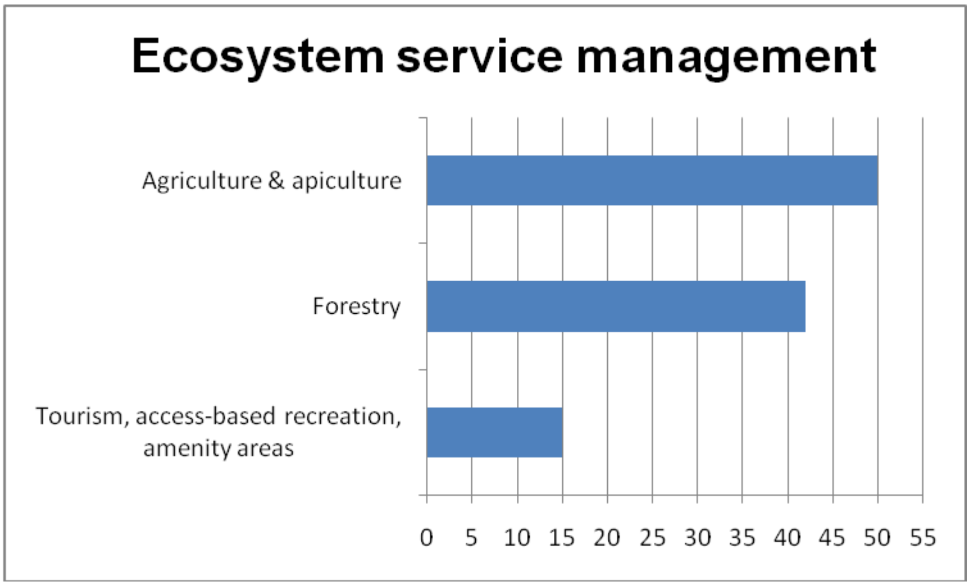

Fig 14. Ecosystem Service management division of model.

Other elements. Of the submitted models, 36 were reported targeting a long-term time horizon while 36 were short-term. In total 33 models applied raster-GIS while only one model applied vector-GIS. Of various decision support paradigms, we collected 1 expert system, 8 multi-criteria analysis models, 15 optimization processes, 96 simulative predictions and 13 other types. Of simulative predictions, 16 were rule-based systems (e.g. qualitative reasoning, rules, rates, environmental ontologies), 24 were individual/cell-based models, 29 were regression models and 16 were reported as other types of simulative predictions. These are described below.

Models of Agriculture and apiculture

Model name Apollo

Acronym **Apollo** Index 180

Web-link http://ddr.nal.usda.gov/bitstream/10113/32442/1/IND44145536.pdf

Subject Ecosystem

Economic

Ecosystem service management Agriculture & apiculture

Description

A prototype decision support system (DSS) called Apollowas developed to assist researchers in using the Decision Support System for Agrotechnology Transfer (DSSAT) crop growth models to analyze precision farming datasets. Because the DSSAT models are written to simulate crop growth and development within a homogenous unit of land, the Apollo DSS has specialized functions to manage running the DSSAT models to simulate and analyze spatially variable land and management. The DSS has modules that allow the user to build model input files for spatial simulations across predefined management zones, calibratethe models to simulate historic spatial yield variability, validate the models for seasons not used for calibration, and estimate the crop response and environmental impacts of nitrogen, plant population, cultivar, and irrigation prescriptions.

Model developer (name, e-mail) Kelly R. Thorp

Modelling paradigm EDDS

Vertical Complexity Decision support system, organizing or enabling several modelling tools

Computing platvorm Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s) C++, VBA

Graphical mapping technology Raster-GIS (grids, pixels)

Geographical applicability area Universal

Time horizon Not specified

Sectoral application area Research (descriptive)

Management

User_friendliness

User inputs — Physical and hydraulic properties of the soil, cultivar, management and weather ratas.

Computational outputs — Average yields

Example

Model name — CQESTR

Acronym — **CQESTR** — Index 17

Web-link — http://www.dbnrrc.ars.usda.gov/Research/docs.htm?docid=13499

Subject — Soil and rock

Ecosystem service management — Agriculture & apiculture

Description

The prospect of storing carbon in soil, as organic matter, provides an opportunity for agriculture to contribute to the reduction of carbon dioxide in the atmosphere. However, a description of management effects on soil description of management effects on soil organic matter (SOM) is necessary to assess carbon storage in soil. A mathematical model, CQESTR, pronounced sequester, has been developed to evaluate the changes in SOM at developed to evaluate the changes in SOM at the field scale.

Model developer (name, e-mail) — dan.long@ars.usda.gov

Modelling paradigm — Simulative prediction

Simulative prediction approach — Rule-based

Vertical Complexity — Decision support system, organizing or enabling several modelling tools

Computing platform — Single computer/PDA

Operating system(s) — Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology — Non-GIS

Geographical applicability area — Universal

Time horizon — Long-term

Sectoral application area

User_friendliness Easy-to-use

User inputs

Computational outputs

User inputs Internal nutrient efficiencies, N, K

Computational outputs

Example We are recalibrating the modified model using field data from 70-year old long-term wheat-fallow rotation experiments at Pendleton, long-term tillage plots at Nebraska, Ohio, and South Carolina, and revalidating with long-term organic matter databases fro

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Model name CROPGRO

Acronym **CROPGRO** Index 13

Web-link http://ecobas.org/www-server/rem/mdb/cropgro.html

Subject Vegetation including fungi

Ecosystem service management Agriculture & apiculture

Description

Irrigation water was applied (i) on reported dates with 3 and 5 days intervals and application rates of 15 and 25 mm or (ii) with automatic irrigation initiated at residual soil moisture levels in the upper 30 cm of the soil profile of 25, 50, or 75%. Three amount levels of N application (100, 200 and 300 kg ha-1 as ammonium nitrate) were considered. A simple economic analysis, including tomato marketable yield and price, irrigation and nitrogen cost and other fixed production costs, was used to estimate expected net return for each management scenario. The model was confirmed to be a useful decision support system to help the farmers to verify the optimal crop management strategy from several points of view.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach Rule-based

Vertical Complexity Decision support system, organizing or enabling several modelling tools

Computing platform Single computer/PDA

Operating system(s)	DOS
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	Soil parameters, weather and soil water content, plant measurements
Computational outputs	Post-harvest root distribution, Leaf area index, Soil water content, Soybean grain yield
Example	Was calibrated for processing tomato in Southern Italy with a 2002

Model name	Decision Support System for Agrotechnology Transfer	
Acronym	**DSSAT**	Index
		25
Web-link	http://www.icasa.net/dssat/	
Subject	Vegetation including fungi	
	Soil and rock	

Ecosystem service management	Agriculture & apiculture

Description

Is a software package integrating the effects of soil, crop phenotype, weather and management options that allows users to ask "what if" questions and simulate results by conducting, in minutes on a desktop computer, experiments which would consume a significant part of an agronomist's career. The new cropping system model now contains models of 17 crops derived from the old DSSAT CROPGRO and CERES models, By incorporating the CENTURY SOM–residue module, DSSAT crop simulation models have become more suitable for simulating low-input systems and conducting long-term sustainability analyses.

Model developer (name, e-mail)	ICASA@icasa.net
Modelling paradigm	EDDS
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Fortran, C, Pascal, Basic
Graphical mapping technology	
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	Management
User_friendliness	Expert assistance required
User inputs	Latitude and longitude of the weather station, daily values of incoming solar radiation (MJ/m^2-day),maximum and minimum air temperature (ºC), and rainfall (mm). Upper and lower horizon depths (cm), percentage sand, silt, and clay centent, 1/3 bar bulk density, organic carbon, pH in water, aluminum saturation, and information on abundance of roots. Planting date, dates when soil conditions were measured prior to planting, planting density, row spacing, planting depth, crop variety, irrigation, and fertilizer practices.
Computational outputs	
Example	

Model name Water, Nutrient and Light Capture in Agroforestry Systems

Acronym **WaNuLCAS** Index 159

Web-link
http://www.worldagroforestry.org/sea/products/AFModels/wanulcas/inside.htm

Subject Water, catchment

Soil and rock

Ecosystem service management	Agriculture & apiculture

Description

The model is conceived as four layers of soil exploited by roots of two components: a crop and a tree. A simple vertical water balance is maintained on the basis of precipitation entering the top layer and drainage leaving the bottom layer. Water leaching downwards carries nutrients, based on the current average concentration in soil solution. Each layer of soil has its own potential uptake of water and nutrient; actual uptake is based on a comparison of the summed potential uptake from all layers and the current 'demand' as determined by the plant biomass. Plant growth is limited by light supply as well as the minimum of relative nutrient and relative water uptake. The two plants interact primarily via the belowground resources and also by shading.A general model on tree soil crop interactions in agroforestry. The model used STELLA.

Model developer (name, e-mail)	M.van-Noordwijk@cgiar.org

Modelling paradigm

Vertical Complexity

Computing platform

Operating system(s)	Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology	Non-GIS

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name	Agricultural Non-Point Source pollution model

Acronym	**AGNPS**	Index

151

Web-link	http://www.ciesin.org/

Subject	Soil and rock

Water, catchment

Ecosystem service management	Agriculture & apiculture

Description

Model developed to examine water quality as it is affected by soil erosion from agriculture and urban areas (Young et al., 1987). It is designed to be executed at the watershed scale.

AGNPS has three major components:

1. hydrology,

2. soil erosion and

3. nutrient pollution.

The hydrological function provides prediction of runoff volume and peak flow rate. The soil erosion function includes soil erosion and sedimentation. The nutrient function analyzes nitrogen, phosphorous and chemical oxygen demand concentration in the runoff and sediment.

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity

Computing platform

Operating system(s)

Modelling language(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name	Data Mining statistical technics for "Software based on advanced decision methods for sustainable agriculture"	
Acronym	**Data Mining**	Index 114
Web-link	http://fmi.unibuc.ro/ro/tema_cercetare_Software_pentru_agricultura/	
Subject	Vegetation including fungi	

Soil and rock

Water, catchment

Ecosystem service management Agriculture & apiculture

Description

The main objective of the project is to elaborate and design a set of models and the appropriate software in order to assist the decision - making of sustainable agriculture.

Model developer (name, e-mail) Denis Enachescu

Modelling paradigm

Vertical Complexity

Computing platform

Operating system(s)

Modelling language(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name Soil-plant system model

Acronym **EXPERT-N** Index

145

Web-link http://www.helmholtz-muenchen.de/en/iboe/expertn/

Subject Soil and rock

Ecosystem service management Agriculture & apiculture

Description

Expert-N is a development system for nitrogen turnover models to simulate the N cycle in arable agriculture. The system consists of modular model components for soil water flow, for soil heat and N transport and for crop growth. These components are built up of different standardized model units representing each a single process as N mineralization for N transport or root water uptake for crop growth. The modular structure allows an easy exchange of model units to compare different submodels or model algorithms describing the same process. For each component and model unit several distinct interchangeable submodels are available and additional user defined submodels can be included easily by the supported use of dynamic link libraries. This enables the user to analyse the impact of different or new modelling approaches on the simulation results component by component. By the modular structure Expert-N is also an extremely flexible simulation model for N dynamics in soil-plant systems, which can be easily adapted to the actual simulation purpose including management or research, to the specific site conditions involving crop, soil and agricultural practice and to the quality and availability of data. Based on a user friendly graphical interface, a windows system for personal computers, Expert-N comprises a menu driven interactive input system to enter all necessary soil, weather, fertilizer and crop data for a particular field and growing season. This and an online help function offering detailed documentations for every model unit allows even users with minimal computing experience to apply Expert-N and to calculate the mass balance and turnover of N in soils. Simulations are further supported by the possibility to display online the development of important state variables such as soil water content, soil temperature, amount of soil nitrate and plant or root biomass.

Model developer (name, e-mail)	Dr. Eckart Priesack
Modelling paradigm	Other
Vertical Complexity	
Computing platform	
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Microsoft Visual C++ (V 1.0)
Graphical mapping technology	
Geographical applicability area	
Time horizon	
Sectoral application area	
User_friendliness	
Example	

Model name	Spatial Modelling Environment	
Acronym	**SME3**	Index
		166
Web-link	http://www.uvm.edu/giee/SME3/	

Subject Ecosystem

Ecosystem service management Agriculture & apiculture

Description

The SME allows a scientist to construct sophisticated models of ecosystems in a point-and-click graphical environment. An ecosystem cell model is developed using a graphical modelling tool STELLA models can simulate photosynthesis, soil chemistry, or any other process operating in a particular kind of landscape. But in isolation, they are like symphony musicians playing in individual sound-proof rooms. The musicians may all be virtuosos, but they can't play in harmony. To behave like an ecosystem, the STELLA models have to be able to "hear" each other. Villa is also gearing up to take the SME concept to the next level with a tool he has dubbed the Integrating Modelling Architecture (IMA). The IMA would allow spatial and non-spatial models to be linked together seamlessly into a high-level model. This will enable researchers to bridge very different kinds of models. For example, a model of the population dynamics of deer (modelling based on individual organisms) could be run within a model of plant growth in a forest (modelling based on a process). The different models could be defined and linked together by dragging and dropping icons on a computer desktop.

Model developer (name, e-mail)	Thomas Maxwell tmaxwell@zoo.uvm.edu
Modelling paradigm	Optimization process
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Modular Modelling Language (MML), C++, Java
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name Soil-Plant-Atmosphere

Acronym **SPA** Index

156

Web-link http://www.geos.ed.ac.uk/homes/mwilliam/spa.html

Subject Water, catchment

Soil and rock

Ecosystem service management Agriculture & apiculture

Description

The Soil-Plant-Atmosphere model (SPA, Williams et. al 1996) is a process-based model that simulates ecosystem photosynthesis and water balance at fine temporal and spatial scales (30 minute time-step, multiple canopy and soil layers).The detailed soil and rooting routines are described in a follow up paper (Williams et al 2001) .The scale of parametrization (leaf-level) and prediction (canopy level) have been designed to allow the model to diagnose eddy flux data, and to provide a tool for scaling up leaf level processes to canopy and landscape scales. The model has been tested in tropical rain forest (Williams et al 1998), and arctic ecosystems (Williams et al 2000).

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity

Computing platform

Operating system(s)

Modelling language(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name Agent-Based Model of Land Use/Cover Change

Acronym **ABM/LUCC** Index

142

Web-link http://jasss.soc.surrey.ac.uk/11/4/4.html

Subject	Soil and rock Vegetation including fungi Economic
Ecosystem service management	Agriculture & apiculture

Description

The model is used to evaluate potential changes in wildfire risk for a Mediterranean landscape and simulates a traditional Spanish agricultural landscape that is undergoing social, demographic and cultural change. We then use maps of land-cover composition and configuration that emerge from the interaction of agents' land-use decision-making to assess potential impacts on wildfire risk. The approach is process-based and considers the behaviour of the actors making the decisions that influence land-use patterns. This model framework allows an improved representation of the impacts of heterogeneous spatial decision-making conditions on individual land holders' decisions.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)?
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C++
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Research (descriptive) Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	Agent Age, Conversion Costs, Land Use, Loss Resilience, Poor Years, Land Tenure, Market Values, Personal Choice, Perspective, proportion of the land used for crops, proportion of the land used for pasture

Example	EU Special Protection Area number 56 (SPA 56) 'Encinares del río Alberche y Cofio', in central Spain.

Model name Expert system for land use in Hungary

Acronym **Landuse Hungary** Index 99

Web-link http://www.tajhasznalat.hu/

Subject Ecosystem

Ecosystem service management Agriculture & apiculture

Description

The algorithms help to choose the appropriate agri-environmental theme depending on the conditions and environment of an agricultural plot. The output is the evaluation of the desired land use.

Model developer (name, e-mail)	ahorvath@botanika.hu
Modelling paradigm	Expert system
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet- linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Hungary (mainly the Great Hungarian Plan)
Time horizon	Long-term
Sectoral application area	Region specific (Hungary)
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	the most important environmental conditions and neighbourhood habitat relations of a given agricultural parcel.

Computational outputs	the evaluation of the selected land use with the following values: (a) the given land use is probably favourable, (b) advantageous, but requires more analyses, (c) risky, regarding ecological sustainability, (e) the given land use must be avoided.
Example	The results of the expert system can be used e.g. in designing the participation of a parcel in agri-environmental programs, or in preparing plans for settlement development

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Model name	Soil-specific agro-ecological strategies for sustainable land use	
Acronym	**MicroLEIS DSS**	Index 94
Web-link	www.microleis.com	
Subject	Socio-environmental Ecosystem Soil and rock	

Ecosystem service management Agriculture & apiculture

Description

Based on the multifunctional evaluation of soil quality, using input data collected in standard soil surveys. Specific agro-ecological strategies to prevent soil degradation in the benchmark sites were designed within two major topics: (i) strategies related to land use planning at a regional level: segregation of agricultural lands, restoration of marginal areas, diversification of crop rotation, and identification of vulnerability areas; and (ii) those related to land management planning at a farm level: organic matter restoration, formulation of tillage practices and workability timing, optimum machinery use, and input rationalization. 12 agro-ecological land evaluation model constituents of MicroLEIS DSS.

Model developer (name, e-mail)	Diego de la Rosa
Modelling paradigm	DSS
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	

Graphical mapping technology	
Geographical applicability area	Spain
Time horizon	
Sectoral application area	Management
User_friendliness	
User inputs	Physical/chemical soil parameters (e.g. useful depth, stoniness, texture, water retention, reaction, carbonate content, salinity, or cation exchange capacity) collected in standard soil surveys, monthly agro-climatic parameters for long-term period, and agricultural crop and management characteristics
Computational outputs	Land use planning is generally aimed at a regional level, and land management at a farm level.
Example	A case study by using MicroLEIS DSS in Sevilla Province (Spain).

Model name	MY-X	
Acronym	**MY-X**	Index
		97
Web-link	http://my-x.hu	
Subject	Water, catchment Fauna Vegetation including fungi Soil and rock Ecosystem Economic Atmosphere including weather Social & institutional Socio-environmental	
Ecosystem service management	Agriculture & apiculture	
Description		

http://miau.gau.hu/myx-free/index.php3?x=i0

http://miau.gau.hu/myx-free/index.php3?x=t01

http://miau.gau.hu/myx-free/index_e9.php3?x=e09

The My-X tool is attempting to provide online data mining services for each decision maker instead of being always intuitive/heuristic with the risk of instability and mistake or instead of using well known data mining tools which cause unacceptable cost (through system administration, servers, analysts, licenses, etc.). The first generation of this online tool provides (as a core method) the similarity analysis, which can be interpreted parallel as a special decision tree, an artificial neural network, benchmarking tool, price/performance optimizer or online expert system: (to say) an universal strategy for interpretation of arbitrary phenomena. The similarity analysis needs only one object-attribute-matrix (OAM) as learning pattern. There are a huge number of parameters, in order to be more efficient. Through the provided advising tools you will know about the parameter setting.The following conversation is to determine if all necessary preconditions are met in order to use the COCO-online standard additive procedure. If not, instructions will be given to help decide which procedure to choose. All your

Model developer (name, e-mail)	Pitlik (László) pitlik@miau.gau.hu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule based
	Regression
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
	Unix
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	
Sectoral application area	Research
	Management
	Education and learning
User_friendliness	
User inputs	attribute-matrix (=learning pattern)
Computational outputs	graphs, expert system (combinatorical space)

Example	Monitoring rural development strategies, variant-analysis, forecasting

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Model name Nature Conservation Information System (TIR)

Acronym **TIR** Index

100

Web-link http://geo.kvvm.hu/tir_en/

Subject Ecosystem

Ecosystem service management Agriculture & apiculture

Description

The primary function of the Nature Conservation Information System is to help the work of national parks and conservation authorities by providing a country-wide database and an application developed specifically for the needs of nature conservation professionals.In addition several pieces of information and many maps are produced within the system, which can be used to provide information for the general public.

Model developer (name, e-mail)	vaczi@mail.kvvm.hu
Modelling paradigm	Other
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platvorm	Single computer/PDA
Operating system(s)	
Graphical mapping technology	
Geographical applicability area	Hungary
Time horizon	
Sectoral application area	Management
User_friendliness	
Example	Nature Conservation Information System

Model name TOOLS, GUIDELINES AND INDICATORS INTEGRATING THE ENVIRONMENTAL CONCERNS INTO AGRICULTURE, FORESTRY AND RURAL WATER POLICY: FROM TOP-DOWN APPROACH TO LOCAL COMMUNITIES INVOLVEMENT

Acronym **TOGI** Index 139

Web-link http://www.icpa.ro/TOGI/

Subject Soil and rock

Ecosystem service management Agriculture & apiculture

Description

System databases, models of interpretation and indicators developed were used to provide information on the implementation and monitoring of codes of good agricultural practice Tools, Guidelines and Indicators Integrating the Environmental Concerns into Agriculture, Forestry and Rural Water Policy: from top-down approach to local communities involvement (TOGI).

Model developer (name, e-mail)

Modelling paradigm Multi-criteria analysis

Vertical Complexity Decision support system, organizing or enabling several modelling tools

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Graphical mapping technology Raster-GIS (grids, pixels)

Geographical applicability area

Time horizon Not specified

Sectoral application area Research (descriptive)

User_friendliness

Example

Model name Multifunctional model for sustainable rural development based on a competitive organic agriculture

Acronym **SIMOCA** Index

Web-link http://www.simoca.org/programmi/home.php?id=51&idarea=6
http://www.gazetadeagricultura.info/index.php?option=com_content&view=article&id=1866:model-multifunctional-de-dezvoltare-rurala-durabila-&catid=83:Turism%20rural&Itemid=142

Subject Socio-environmental

Ecosystem service management Agriculture & apiculture

Description

The general objective of the project is to define a new strategy for sustainable and multifunctional rural development based on the growth of organic farming.For this purpose, territorial integration between CADSES countries has to be favoured by promoting meetings and exchange of knowledge between different bodies that promote land development (decision makers, end-users, etc.) by setting up international networks and favouring knowledge exchange. The project was formulated to answer to the main problem between the selected countries that is the lack of a sustainable rural development strategy that integrates socio-economic, agricultural, cultural and environmental aspects.

Model developer (name, e-mail)

Modelling paradigm Multi-criteria analysis

Vertical Complexity Published statistical relationship (regression, rate or other formula)

Computing platform

Operating system(s)

Graphical mapping technology Non-GIS

Geographical applicability area CADSES countries

Time horizon Long-term

Sectoral application area

User_friendliness

Example

Model name Soil Water and CROP production model

Acronym **SWACROP** Index

7

Web-link http://www.bib.wau.nl/dlo/sc-dlo.html

Subject Water, catchment

Soil and rock

Ecosystem

Ecosystem service management Agriculture & apiculture

Description

Keywords: unsaturated zone, soil evaporation, soil water, crop production, soil water flow, potato, wheat, maize, grass, irrigation, drainage

Is a transient one-dimensional finite difference model for simulation of the unsaturated zone. It incorporates the process of water uptake by roots. The soil profile is divided into several layers (containing one or more compartments of variable thickness) having different physical properties. SWACROP (Soil WAter and CROP production model) is a transient one-dimensional finite difference model for simulation of the unsaturated zone. It incorporates the process of water uptake by roots. The soil profile is divided into several layers (containing one or more compartments of variable thickness) having different physical properties. The partial differential equation for flow in the unsaturated system is solved using an implicit finite difference scheme. An explicit linearization of the hydraulic conductivity (K) and soil water capacity (C) is used. Knowing the initial conditions (i.e. water content or pressure head distribution profile) and top and bottom boundary conditions, the system of equations for all the compartments is solved for each (variable) time step by applying the so-called Thomas tridiagonal algorithm. The integration procedure within each time step allows calculation of all water balance terms for each time period selected. For the top boundary, data on rainfall, potential soil evaporation, and potential transpiration are required. When the soil system remains unsaturated, one of three bottom boundary conditions can be used: pressure head, zero flux, or free drainage. When the lower part of the system remains saturated, one can either give the ground-water level or the flux through the bottom of the system as input. In the latter case, the ground-water level is computed. The rate of vegetation growth, both potential and actual can be simulated in the crop growth submodel which is linked to the main water model in a dynamic way. This submodel supplies information about the vegetation characteristics to the main water model throughout the simulation period. However, both models can be run separately.

Model developer (name, e-mail) wesseling@sc.agro.nl

Modelling paradigm Simulative prediction

Simulative prediction approach finite differences

Vertical Complexity Published statistical relationship (regression, rate or other formula)

Computing platform Single computer/PDA

Operating system(s) DOS

Modelling language(s) FORTRAN-77

Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	the hydraulic conductivity (K) and soil water capacity (C), data on rainfall, potential soil evaporation, and potential transpiration, pressure head, zero flux, or free drainage
Computational outputs	the ground-water level, the rate of potential and actual vegetation growth
Example	

Model name	2D Ground Water Salt-Heat Transport with Freezing	
Acronym	**2D_V_HYDRO_S**	Index 150
Web-link	http://dino.wiz.uni-kassel.de/model_db/mdb/2d_v_hydro_s.html	
Subject	Water, catchment	
	Soil and rock	
Ecosystem service management	Agriculture & apiculture	

Description

The 2D-V-HYDRO-S program can model transient or steady-state two-dimensional profile flows of ground water with contaminant transport and heat transport added with account of freezing. One can turn off the heat or/and salt transport if it is necessary. The region of the modelling is bounded by earth surface, impermeable bottom, river bank slopes, and vertical lines of symmetry. Drains, vertical impermeable screens, and freezing columns can be inside of the region. Infiltration of fresh or salt water or evaporation can be from the earth too. The ground is supposed be lithologically layered.The modelling is based on: 1) a hydrodynamical model of groundwater filtration with incomplete pore saturation, 2) an equation of convective dispersion for contaminant transport, 3) an equation of heat transport and heat conductivity with account of freezing, 4) soil/water and salt/heat relations. The model is implemented with the help of finite-difference approximations on non- uniform grids and new iterative techniques of the incomplete factorization method. There is a version of the program which takes into account a cation exchange of Na, Ca, and Mg. Output results computed at given times are grid values and isolines of head, water content, concentration, and temperature, as far as integrated parameters of the flows, boundaries of saturated zones and frozen zones of the region. Pictures of the isolines can be saved in PCX-files.

The program takes input data from a text file which can be created by a special utility. The utility uses a mouse to set all parameters of the problem in visual interactive mode.

The program can be used to calculate ground water flows through a damb, to systematical or another horizontal drainage, under heavy buildings, from surface or inner sources of pollution, between frozen or another screens, to river banks, from channels, and in combinations of these conditions. It calculates salt and heat transport by these flows, too.

2D, irrigation, drainage, incomplete saturation, contaminant transport, heat, freezing, soil water transport, variably saturated soil.

Model developer (name, e-mail)	V.I.Sabinin sabinin@hydro.nsc.ru
Modelling paradigm	Optimization process
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	DOS
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	
Sectoral application area	
User_friendliness	
User inputs	Geometrical parameters of a flow region and of artificial objects inside. Lithological parameters of ground layers and parameters of formulae approximating functions of water content versus capillary pressure and hydraulic conductivity versus water content. Salt and heat parameters of the ground and water. Initial grid values of head, concentration, temperature. Boundary values of infiltration, concentration, temperatures stepped functions of time. Precision constants for finishing iteration processes.
Computational outputs	Outputs are grid values and isolines of head, water content, concentration, and temperature, as far as

integrated parameters of the flows, boundaries of saturated zones and frozen zones of the region. Digit values are accumulated in a text file and pictures of the isolines can be saved in PCX-files.

Example

Model name 2DSOIL

Acronym **2DSOIL** Index 23

Web-link http://www.ars.usda.gov/Research/docs.htm?docid=6339

Subject Modelling language(s)

Ecosystem service management Agriculture & apiculture

Description

Is a comprehensive 2-dimensional model of soil and root processes to track agricultural impact on water quality. The soil simulator that could easily be modified and incorporated into crop models. To model root activity and soil infiltration in and around a corn plant especially in response to nitrogen stress. 2DSOIL was used to simulate the effect of several water and nitrogen management practices and was incorporated into ARS potato and cotton models, into the Root Zone Water Quality Model, and into the USGS Modular Modelling System.

Model developer (name, e-mail)	dtimlin@asrr.arsusda.gov
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	DOS
Modelling language(s)	FORTRAN
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)

	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	the soil moisture probes, temperature
Computational outputs	The spatial and temporal distribution of soil moisture as a function of nitrogen plant stress.
Example	Was incorporated into ARS potato and cotton models, into the Root Zone Water Quality Model, and into the USGS Modular Modelling System.

Model name	The Agricultural Policy Environmental eXtender	
Acronym	**APEX**	Index 163
Web-link	http://epicapex.brc.tamus.edu/	
Subject	Water, catchment	
	Soil and rock	

Ecosystem service management — Agriculture & apiculture

Description

The model can be configured for novel land management strategies, such as filter strip impacts on pollutant losses from upslope crop fields, intensive rotational grazing scenarios depicting movement of cows between paddocks, vegetated grassed waterways in combination with filter strip impacts, and land application of manure removal from livestock feedlots or waste storage ponds. The APEX model is a flexible and dynamic tool that is capable of simulating management and land use impacts for whole farms and small watersheds. APEX is essentially a multi-field version of the predecessor EPIC model. The model consists of 12 major components: climate, hydrology, crop growth, pesticide fate, nutrient cycling, erosion-sedimentation, carbon cycling, management practices, soil temperature, plant environment control, economic budgets, and subarea/routing.

Model developer (name, e-mail)	Philip Gassman
Modelling paradigm	Simulative prediction
Simulative prediction approach	Regression

Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
	Unix
Modelling language(s)	FORTRAN
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	climat, irrigation
Computational outputs	Carbon-, nitrogen, phosphorus cycling, Water and wind erosion, hyrdologic balance, livestock grazing, manure management
Example	NPP project

Model name AZODYN

Acronym **AZODYN** Index 24

Web-link http://publication.isara.fr/article.php3?id_article=49

Subject Vegetation including fungi

Ecosystem service management Agriculture & apiculture

Description

Wheat crop model as a cultivar decision support tool using a set of 14 genotypes, tested in 21 contrasting environments. The results showed that the Azodyn crop model satisfactorily simulated yield and grain protein content for a large range of genotypes and environments. Assist to farmers for the fertilization management. Soil module simulates changes in the amount of mineral N in the soil over the crop cycle, the fertilizer module simulates the daily net mineralization, volatization and nitrogen use efficienty of the fertilizer. The crop module simulates leaf area time-course change, according to nitrogen accumulation in the crop.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	Regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	daily climatic data, soil characteristics, ground biomass
Computational outputs	predicted N soil availability, grain yield, grain protein content and mineral N in the soil
Example	

Model name	The CENTURY Soil Organic Matter Model	
Acronym	**CENTURY**	Index 152
Web-link	http://www.nrel.colostate.edu/projects/century5/	
Subject	Water, catchment	

Soil and rock

Ecosystem service management	Agriculture & apiculture

Description

The CENTURY version 5 agro ecosystem model is the latest version of the soil organic model developed by Parton et al. (1987). This model simulates C, N, P, and S dynamics through an annual cycle over time scales of centuries and millennia. The producer submodel may be a grassland/crop, forest or savanna system, with the flexibility of specifying potential primary production curves representing the site-specific plant community. CENTURY was especially developed to deal with a wide range of cropping system rotations and tillage practices for system analysis of the effects of management and global change on productivity and sustainability of agroecosystems. Version 4 of the model integrated the effects of climate and soil driving variables and agricultural management to simulate carbon, nitrogen, and water dynamics in the soil-plant system. Simulation of complex agricultural management systems including crop rotations, tillage practices, fertilization, irrigation, grazing, and harvest methods is now possible. Version 5 includes a layered soil physical structure, and new erosion and deposition submodels. The model code has been rewritten in C++, reorganized, and modified to use platform-independent configuration and output files. Added to this version is graphical-user interface providing ease of configuration and running CENTURY simulations, the Century Model Interface.

The CENTURY model embodies our best understanding to date of the biogeochemistry of carbon, nitrogen, phosphorus, and sulphur. The primary purposes of the model are to provide a tool for ecosystem analysis, to test the consistency of data and to evaluate the effect of changes in management and climate on ecosystems. Evolution of the model will continue as our understanding of biogeochemical processes improves. The identification of problem areas where processes are not adequately quantified is key to further developments. Ideally, model application will lead to the identification of needed research and new experimentation to improve understanding.

Version 5 includes a layered soil physical structure, and new erosion and deposition submodels. The model code has

Model developer (name, e-mail)	Dr. Dennis Ojima dennis@nrel.colostate.edu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C++

Graphical mapping technology Non-GIS

Geographical applicability area

Time horizon Short-term

Sectoral application area

User_friendliness

Example

Model name CERES

Acronym **CERES** Index 26

Web-link http://nowlin.css.msu.edu/wheat_book/

Subject Vegetation including fungi

Ecosystem service management Agriculture & apiculture

Description

The model simulate the effects of cultivar, planting density, weather, soil water, and nitrogen on crop growth, development, and yield. Is a simulation the averaged conditions for wheat, barley and mayze that describes daily phenological development and growth in response to enviromental factors (soil, weather and management). The model is useful for prediction and control at the farm and regional level.

Model developer (name, e-mail) Dr. Joe T. Ritchie

Modelling paradigm Simulative prediction

Simulative prediction approach Regression

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platvorm Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s) FORTRAN

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon	Short-term
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	solar radiation, rainfall, air temperature and potential evapotranspiration, carbohydrates, cellulose- and lignin-like
Computational outputs	Soil water balance, soil mineral nitrogen, soil carbon, crop growth and yield
Example	1. Have been tested within the framework of an INCO-COPERNICUS project against independent data from the typical agricultural practice in Bulgaria to predict acceptably water balance and nitrogen losses.

Model name	CLUE Modelling Framework is a dynamic, multi-scale land use and land cover change model	
Acronym	**CLUE**	Index
		171
Web-link	http://www.cluemodel.nl/	
Subject	Ecosystem	
Ecosystem service management	Agriculture & apiculture	
Description		

The objective of CLUE is to make a spatially explicit, multi-scale, quantitative description of land use changes through the determination and quantification of the most important (assumed) bio-geophysical and human drivers of agricultural land use on the basis of the actual land use structure. Results of this analysis are incorporated into a (dynamic) model, which describes changes in the area of the different land use types. Besides tracking past or historical land use changes, the objective is to explore possible land use changes in the near future under different development scenarios, having a time horizon of about 20 years. The CLUE methodology is based on the analysis of land use systems as complex, multi-level systems. Land use systems operate at the interface of multiple social and ecological systems. Economic models and/or existing projections are used in the non-spatial demand module, which calculates the area of change demanded for by the different sectors of the economy.

Model developer (name, e-mail) http://www.lad.wur.nl

Modelling paradigm Multi-criteria analysis

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Not specified

Sectoral application area Research (descriptive)

User_friendliness Expert assistance required

Example

Model name Coupled heat and mass transfer model for soil-plant-atmosphere system

Acronym **COUPMODEL** Index 146

Web-link http://www.lwr.kth.se/Vara%20Datorprogram/CoupModel/

Subject Water, catchment

Soil and rock

Ecosystem service management Agriculture & apiculture

Description

Purpose

To quantify and increase the understanding concerning basic hydrological and biological processes in the soil-plant-atmosphere system.

The model simulates soil water and heat processes in many type of soils; bare soils or soils covered by vegetation. The basic structure of the model is a depth profile of the soil. Processes such as snow-melt, interception of precipitation and evapotranspiration are examples of important interfaces between soil and atmosphere. Two coupled differential equations for water and heat flow represent the central part of the model. These equations are solved with an explicit numerical method. The basic assumptions behind these equations are very simple:

(i) The law of conservation of mass and energy and

(ii) flows occur as a result of gradients in water potential (Darcy's Law) or temperature (Fourier's law).

The calculations of water and heat flows are based on soil properties such as: the water retention curve, functions for unsaturated and saturated hydraulic conductivity, the heat capacity including the latent heat at thawing/melting and functions for the thermal conductivity. The most important plant properties are: development of vertical root distributions, the surface resistance for water flow between plant and atmosphere during periods with a non limiting water storage in the soil, how the plants regulate water uptake from the soil and transpiration when stress occurs, how the plant cover influences both aerodynamic conditions in the atmosphere and the radiation balance at the soil surface.

All of the soil-plant-atmosphere system properties are represented as parameter values. Meteorological data are driving variables to the model. Most important of those are precipitation and air temperature but also air humidity, wind speed and cloudiness are of great interest. Results of a simulation are such as: temperature, content of ice, content of unfrozen water, water potential, vertical and horizontal flows of heat and water, water uptake by roots, storages of water and heat, snow depth, water equivalent of snow, frost depth, surface runoff, drainage flow and deep percolation to ground water.

In addition to the water and heat conditions also the plant dynamics and related turnover of nitrogen and carbon may be simulated. The abiotic and biotic processes may be linked in different ways also to handle the feedback between the physical driving forces and the plant development.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	Finite difference
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	
Graphical mapping technology	
Geographical applicability area	
Time horizon	
Sectoral application area	
User_friendliness	

User inputs	precipitation and air temperature but also air humidity, wind speed and cloudiness.
Computational outputs	temperature, content of ice, content of unfrozen water, water potential, vertical and horizontal flows of heat and water, water uptake by roots, storages of water and heat, snow depth, water equivalent of snow, frost depth, surface runoff, drainage flow and deep percolation to ground water.
Example	

Model name	Cropping Systems Simulation Model	
Acronym	**CropSyst**	Index 91
Web-link	http://www.bsyse.wsu.edu/cropsyst/	
Subject	Vegetation including fungi Soil and rock	

Ecosystem service management Agriculture & apiculture

Description

Is a multi-year, multi-crop, daily time step crop growth simulation model, developed with emphasis on a friendly user interface, and with a link to GIS software and a weather generator. CropSyst simulates the soil water budget, soil-plant nitrogen budget, crop phenology, crop canopy and root growth, biomass production, crop yield, residue production and decomposition, soil erosion by water, and pesticide fate.

Model developer (name, e-mail)	Stockle and Nelson, 1996
Modelling paradigm	Simulative prediction
Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C++
Graphical mapping technology	Raster-GIS (grids, pixels)

Geographical applicability area Universal

Time horizon Short-term

Sectoral application area Management

Reseach (descriptive)

User_friendliness

User inputs

Computational outputs

Example

Model name Erosion-Productivity Impact Calculator

Acronym **EPIC** Index

164

Web-link http://epicapex.brc.tamus.edu/

Subject Soil and rock

Water, catchment

Ecosystem service management Agriculture & apiculture

Description

EPIC, a cropping systems simulation model, was developed to estimate soil productivity as affected by erosion throughout the United States during the 1980's. It was a response to the first Resources and Conservation Act (RCA) appraisal conducted in 1980, which revealed a significant need for improved technology for evaluating the impacts of soil erosion on soil productivity. EPIC simulates all crops with one crop growth model using unique parameter values for each crop. The processes simulated include leaf interception of solar radiation; conversion to biomass; division of biomass into roots, above ground mass, and economic yield; root growth; water use; and nutrient uptake. EPIC is a field scale, daily time step model composed of physically based components for soil and crop processes such as erosion, nutrient balance, crop growth, and related processes. It is designed to simulate drainage areas that are characterized by homogeneous weather, soil, landscape, crop rotation, and management. Since the initial development, EPIC has been continually improving through the additions of algorithms to simulate water quality, climate change and the effect of atmospheric CO2concentration, and nitrogen and carbon cycling.

Model developer (name, e-mail) Todd Campbell elvis@iastate.edu

Modelling paradigm Simulative prediction

Simulative prediction approach	Regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Fortran
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	Soil, weather, tillage and crop parameter data supplied with model.
Computational outputs	
Example	

Model name	Agricultural Household Model	
Acronym	**GAMS**	Index 144
Web-link	http://www.reap.ucdavis.edu/research/Agricultural.pdf	
Subject	Economic	
Ecosystem service management	Agriculture & apiculture	
Description		

This model to explore household-level impacts of agricultural policy changes on production and incomes under alternative rural-market scenarios. Household-farm models are a useful tool to study how household-specific transaction costs shape the impacts of exogenous policy and market changes in rural areas. We use the model to explore household-level impacts of agricultural policy changes under the North American Free-Trade Agreement

(NAFTA) on production and incomes under alternative rural-market scenarios. A model was needed to explain the economic behavior of: (1) the net-surplus producing family farm, typical of small owner-operated farms of medium productivity; (2) the subsistence and sub-subsistence household farm, typical of small-scale, low productivity agriculture, frequently operating under marginal conditions and incomplete markets; (3) small-scale renter and sharecropper farms; and (4) the owner-operated commercial farms producing food for both domestic consumption and agro-industry and export markets.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell based (agents)?
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	Not specified
Sectoral application area	Research (descriptive)
	Management
User_friendliness	
User inputs	goods
	household-produced goods
Computational outputs	full profit
Example	Mexican village

Model name	Genotype-by-Environment interaction on CROp growth Simulator	
Acronym	**GECROS**	Index 157

Web-link http://www.csa.wur.nl/UK/Downloads/Gecros/?wbc_purpose=Basic&WBCMODE=PresentationUnpublished

Subject Soil and rock

Ecosystem service management Agriculture & apiculture

Description

The model uses robust, yet simple algorithms to summarize the current knowledge of individual physiological processes and their interactions and feedback mechanisms. It was structured from the basics of whole-crop systems dynamics to embody the physiological causes rather than descriptive algorithms of the emergent consequences. It also attempted to model each process at a consistent level of detail, so that no area is overemphasized and similarly no area is treated in a trivial manner. Main attention has been paid to interactive aspects in crop growth such as photosynthesis-transpiration coupling via stomatal conductance, carbon-nitrogen interaction on leaf area index, functional balance between shoot and root activities, and interplay between source supply and sink demand on reserve formation and remobilization. GECROS combines robust model algorithm, high computational efficiency, and accurate model output with minimum number of input parameters that require periodical destructive sampling to be estimated.

Model developer (name, e-mail)

Modelling paradigm Multi-criteria analysis

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s) FSTWin

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Not specified

Sectoral application area Management

User_friendliness

Example

Model name Generic analysis and extrapolation of oilseed rape dispersal

Acronym **GenEERA** Index

30

Web-link http://www.gmo-safety.eu/database/937.geneera-modelling-dispersal-behaviour-oilseed-rape-landscape-scale-overall-coordination.html

Subject Vegetation including fungi

Ecosystem service management Agriculture & apiculture

Description

Within the GenEERA joint project a method spectrum was developed that covers the description on a small scale of the processes involved in the spread and persistence of oilseed rape transgenes and enables upscaling of different local characteristics. The simulation models RegioPol and GeneTraMP were key elements. With the help of these models it was possible to simulate the development of individual rape plants and oilseed rape populations. The base information consisted of cultivation densities (analysis of satellite pictures, agricultural statistics), meteorological data (temperature, wind, precipitation, sunshine), maps (including classification of natural landscapes), the ecology of oilseed rape and related species and their dispersal data. The model can be used to investigate the interaction between the different effect paths.

Model developer (name, e-mail)	hauke.reuter@uni-bremen.de
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	
Operating system(s)	
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	
User_friendliness	Expert assistance required
User inputs	climate conditions, analysis of satellite pictures, agricultural statistics, agricultural statistics, wind direction and force.
Computational outputs	result for the survival of ruderal plants, distribution and persistence of rape transgenes.
Example	The models developed by the GenEERA project (GeneTraMP and RegioPol) are now available as a flexible instrument for depicting the spread of oilseed rape within the landscape framework of Northern

Germany and for making preliminary forecasts.

Model name GeneSys

Acronym **GeneSys** Index

32

Web-link

http://www.prodinra.inra.fr/prodinra/pinra/doc.xsp?id=PROD2008f09ac2b2&uri=%2Fnotices%2Fprodinra1%2F2009%2F02%2F&base=notices&qid=sdx_q0&p=1&n=3&

Subject Vegetation including fungi

Ecosystem service management Agriculture & apiculture

Description

Using the GENESYS model quantifying the effect of cropping systems on gene escape from GM rape varieties to evaluate and design cropping systems. The spatio-temporal framework of GENESYS consists in simulating every year the life-cycle of the modelled crop relative in each field of a given region.

Model developer (name, e-mail)	Colbach jfazio@nwcouncil.org
Modelling paradigm	Simulative prediction
Simulative prediction approach	Monte Carlo simulation
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	

User inputs | The map of the simulated agricultural landscape, soil texture, moisture and structure, the seed bank, daily weather data, the crop succession

Computational outputs

Example

Model name Software based on advanced decision methods for sustainable agriculture

Acronym **Library RIMODLib** Index 109

Web-link http://www.rimod.ici.ro/

Subject Other

Ecosystem service management Agriculture & apiculture

Description

Library RIMODLib – "Set of software applications (based on models) of decision support type ". Library RIMODLib has three components (based on type of models). The components are: a. RIMOD-OLAP - Multidimensional analysis of data (OLAP-On Line Analitical Processing; b. RIMOD-DEC - Multicriteria decision and c. RIMOD-PREMIN - Prediction and data mining.

Model developer (name, e-mail)

Modelling paradigm Optimization process

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name LPJ Dynamic Global Vegetation Model

Acronym **LPJ DGVM** Index 155

Web-link http://www.pik-potsdam.de/research/cooperations/lpjweb

Subject Water, catchment

Soil and rock

Ecosystem service management Agriculture & apiculture

Description

LPJ is a dynamic global simulation model of vegetation biogeography and vegetation/soil biogeochemistry. Taking climate, soil and atmospheric information as input, it dynamically computes spatially explicit transient vegetation composition in terms of plant functional groups, and their associated carbon and water budgets. LPJmL additionally simulates the carbon and water budgets of agricultural lands and of land use change; it is being extended to include forestry. It takes as inputs land use and land management data.

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Internet-linked Servers

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name Matricial Approach to POllen Dispersal

Acronym **MAPOD** Index

31

Web-link
http://www.international.inra.fr/partnerships/with_the_private_sector/live_from_the_labs/predicting_pollen

Subject Vegetation including fungi

Ecosystem service management Agriculture & apiculture

Description

Designed to predict cross-pollination rates between maize fields in a spatially explicit agricultural landscape under varying cropping and climatic conditions. Pollen exchanges between GM and non-GM maize crops are simulated and influencing factors such as field sizes and shapes, distribution of GM and non-GM fields in the agricultural landscape as well as flowering dates and dynamics are integrated. Model parameter values were either derived from existing models of pollen dispersal or estimated from experimental field studies. The Land flow-gene generic platform, which models gene flow at the scale of agricultural landscapes, was developed in the context of the European SIGMEA programme (see Newsletter No. 20). It includes two models designed by INRA: GeneSys® for rapeseed and MAPOD® for maize. The latter can predict the cross-pollination rates between maize plots present in a small farming region. It has already been used during several studies to estimate the impact of introducing GM maize varieties on the adventitious presence of GM impurities in non-GM crops, and to test the efficiency of certain GM/non-GM co-existence strategies.

Model developer (name, e-mail)	Frederique.Angevin@jouy.inra.fr
Modelling paradigm	Simulative prediction
Simulative prediction approach	Normal Inverse Gaussian model
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Management
User_friendliness	Easy-to-use

User inputs

Computational outputs

User inputs	Certain traits of the varieties and certain agricultural practices for each maize field as well as climatic factors for the given region. Growing degree days
Computational outputs	Amount of pollen
Example	varying cropping

Model name Automated System for Evaluating and Management the Natural Soil Fertility

Acronym	**MARISMA**	Index 19
Web-link	http://www.evenor-tech.com/microleis/microlei/microlei.aspx	
Subject	Wetland	
	Vegetation including fungi	

Ecosystem service management Agriculture & apiculture

Description

Gives special emphasis to the soil chemical quality, but also considers several soil physical parameters related with the textural class.

Model developer (name, e-mail)	D. de la Rosa
Modelling paradigm	Simulative prediction
Simulative prediction approach	Qualitative
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified

Sectoral application area Research (descriptive)

User_friendliness Easy-to-use

User inputs

Computational outputs

Example

Model name PolFlow

Acronym **PolFlow** Index 99

Web-link http://www.dsi.gov.tr/english/congress2007/chapter_3/93.pdf

Subject Water, catchment

Ecosystem service management Agriculture & apiculture

Description

The PolFlow model is embedded in PCraster, a raster based GIS modelling tool [De Wit, 1999]. The model contains three factors that are seen as determinant to describe water fluxes [Greffe, 1999]. The long term average total runoff, the groundwater recharge index, and the groundwater residence time are the determinant factors in the model.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach Rule-based

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Graphical mapping technology Raster-GIS (grids, pixels)

Geographical applicability area Universal

Time horizon Long-term

Sectoral application area Research (descriptive)

Management

User_friendliness

User inputs — Average annual precipitation and temperature, hydrogeological map, digital Elevation Model, Slope, land cover, soil map, Discharge data for rivers.

Computational outputs — Quantity of surface and groundwater. Nutrient transport (nitrogen, phosphorus) in the drainage basin. Average total runoff or precipitation surplus

Example

Model name — Pro Planta cost-effective environmentally sound fertilization guide system

Acronym — **Pro Planta** — Index 99

Web-link — http://www.proplanta.hu/index.html

Subject — Soil and rock

Ecosystem service management — Agriculture & apiculture

Description

This software has the innovation award in 2007. Software is modelling the relationships between fertilization methods, soil composition and yields based on the fertilization researches of the last decades. Data should be provided on the cultivated vegetation (earlier and actual), soil composition, and the expected yield. According to this four fertilization strategy is calculated. 1 and 2 are for reaching the maximum economical yield with middle soil PK provision, 3 and 4 are for the maximum yield with low fertilization. Actually 48 cultivated plants, 45 vegetables and 15 standing crop and grapes is included in this decision-helping software. The data and analyses can be saved and printed.

Model developer (name, e-mail) — fodornandor@rissac.hu

Modelling paradigm — Simulative prediction

Simulative prediction approach — Rule-based

Vertical Complexity — Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s)

Modelling language(s)	Hungarian
Graphical mapping technology	
Geographical applicability area	Hungary
Time horizon	
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	Data should be provided on the cultivated vegetation (earlier and actual), soil composition, and the expected yield.
Computational outputs	According to this four fertilization strategy is calculated. 1 and 2 are for reaching the maximum economical yield with middle soil PK provision, 3 and 4 are for the maximum yield with low fertilization.
Example	Actually 48 cultivated plants, 45 vegetables and 15 standing crop and grapes is included in this decision-helping software for cost-effective environmentally sound fertilization

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Model name	Quantitative Evaluation of the Fertility of Tropical Soils	
Acronym	**QUEFTS**	Index 18
Web-link	http://www.prem-online.org/index.php?p=publications&a=show&id=108	
Subject	Vegetation including fungi Soil and rock	
Ecosystem service management	Agriculture & apiculture	

Description

Quantitatively estimate optimal fertilizer requirements to alleviate the problems of the crops. Was used to estimate region-specific nitrogen (N), phosphorus (P) and potassium (K) requirements as well as fertilizer applications needed to realize target yields of wheat and maize. QUEFTS predicts crop yields from chemical soil characteristics, assuming all other production factors are optimal. While the assumption may not be realistic, QUEFTS can still be used as an indicator of soil fertility.

Model developer (name, e-mail)	Ingrid Mulder
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	Internal nutrient efficiencies, N, K
Computational outputs	
Example	China, India, Benin

Model name SALTMED

Acronym **SALTMED** Index 14

Web-link

http://www.nerc-wallingford.ac.uk/research/cairoworkshop/papers/publishedSALTMED.pdf

Subject Water, catchment

Soil and rock

Ecosystem service management	Agriculture & apiculture

Description

The SALTMED model includes the following key processes: evapotranspiration, plant water uptake, water and solute transport under different irrigation systems, drainage and the relationship between crop yield and water use. Accounts for the combined impact of water and osmotic stresses on biomass production and final yield and hence on the farmer's income. Has a water uptake function that accounts for vertical and horizontal root distribution while existing models only account for the vertical distribution in the best case. Is a model that runs for saline and non saline conditions. As such, it is applicable to any condition any where. Is a tool for use by experts in the management of salt-prone irrigation systems.

Model developer (name, e-mail)	R. Ragab Rag@ceh.ac.uk
Modelling paradigm	Simulative prediction
Simulative prediction approach	Richards and Convection-Dispersion Equation
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C/C++
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	Short-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	Plant characteristics, soil characteristics, meteorological data, water management data
Computational outputs	yield, potential and actual water uptake, salinity, soil matrix potential, soil moisture profiles, crop water requirements, plant growth
Example	Field observations from Egypt and Syria.

Model name Simultaneous Heat and Water Model

Acronym **SHAW** Index 3

Web-link http://www.ars.usda.gov/research/publications/publications.htm?SEQ_NO_115=227666

Subject Water, catchment

Soil and rock

Ecosystem

Ecosystem service management Agriculture & apiculture

Description

The SHAW model simulates a one-dimensional vertical profile extending from the top of a plant canopy or the snow, residue or soil surface to a specified depth within the soil. The system is represented by integrating detailed physics of vegetative cover, snow, residue and soil into one simultaneous solution. SHAW model to simulate the surface radiation exchange within wheat, corn, and soybean canopies was tested. Based on simulation results, the SHAW model can reasonably simulate the surface radiation balance, but weaknesses in the model for simulating within canopy radiation exchange were identified.

Model developer (name, e-mail)	gerald.flerchinger@ars.usda.gov
Modelling paradigm	Simulative prediction
Simulative prediction approach	
Simulative prediction	
Simulative prediction approach	approach Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	DOS
Modelling language(s)	Fortran77
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal

Time horizon	Short-term
Sectoral application area	
User_friendliness	
User inputs	Temperature to distinguish rain from snow. Plant height, leaf area index, and resistance parameters. Plant residue layer thickness and percent cover. Soil albedo and hydraulic properties.
Computational outputs	Surface energy balance, snow depth, snow density, liquid water content of snow, evaporation, transpiration, and soil profiles of temperature, water, ice and solutes.
Example	

Model name	Simulateur multidisplinaire pour les Cultures Standard	
Acronym	**STICS**	Index 15
Web-link	http://www.avignon.inra.fr/agroclim_stics_eng	
Subject	Socio-environmental Vegetation including fungi	

Ecosystem service management Agriculture & apiculture

Description

Its main aim is to simulate the effects of the physical medium and crop management schedule variations on crop production and environment at the field scale. Is a dynamic, daily time-step model which simulates the behaviour of a soil-crop system over the period of a year. From the characterization of climate, soil, species and crop management, it computes output variables relating to yield in terms of quantity and quality, environment in terms of drainage and nitrate leaching, and to soil characteristics evolution under cropping system. Adaptability to a variety of crops (wheat, maize, soy, sorghum, flax, grasslands, tomatoes, beet, sunflower, peas, oil seed rape, bananas, sugar cane, carrots, lettuce, etc.),

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for

	practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Fortran77
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	climate, soil and the cropping system
Computational outputs	production (quantity and quality), the environment and variations in soil characteristics in cropping situations
Example	

Model name	Simple and Universal CROp growth Simulator	
Acronym	**SUCROS**	Index 156

Web-link
http://www.cwe.wur.nl/UK/Downloads/SUCROS/?wbc_purpose=Basic&WBCMODE=PresentationUnpublished

Subject	Soil and rock
	Water, catchment
Ecosystem service management	Agriculture & apiculture

Description

Two versions of the simulation model for crop growth SUCROS (Simple and Universal CROp growth Simulator) are described, one for potential production (SUCROS1) and one when water is limiting (SUCROS2).The model is applied to spring wheat, with ample supply of nutrients, and without pests, diseases and weeds. Radiation and temperature (and precipitation in SUCROS2), being the most important environmental factors, and crop characteristics determine growth and development. Crop growth and development are simulated based on underlying chemical, physiological and physical processes. Dry matter accumulation is calculated from daily crop CO2 assimilation based on leafCO2 assimilation and taking into account the respiration costs and allocation of carbohydrates to different plant parts. Following the model listings, the statements are explained step by step. In water-limited situations, the soil water balance is calculated according to the tipping-bucket system. The Penman-Monteith combination is used to calculate potential evapotranspiration. To account for the effect of water shortage, potential daily total gross CO2 assimilation of the crop is

Model developer (name, e-mail)	
Modelling paradigm	Multi-criteria analysis
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	DOS
Modelling language(s)	Fortran
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Management
User_friendliness	
User inputs	dry matter in leaves, stems and roots, Daily maximum and minimum temperatures
Computational outputs	Total drainage, total interception, total runoff
Example	

Model name	SWAP	
Acronym	**SWAP**	Index 11
Web-link	http://www.swap.alterra.nl/	

Subject	Water, catchment Ecosystem Soil and rock
Ecosystem service management	Agriculture & apiculture
Description	

The ecosystem model is designed to simulate flow and transport processes at field scale level, during growing seasons and for long term time series. Keywords: water management, crop production, solute transport, soil water flow, bypass flow, soil shrinkage, soil cracking, crack flow, preferential flow, hydraulic functions, hysteresis, heat dynamics, solute dynamics, evaporation, irrigation scheduling, drainage

Model developer (name, e-mail)	swap.alterra@wur.nl
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based - Richards equation
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	DOS
Modelling language(s)	Fortran
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	Daily meteorological input data, Soil water flow, Soil heat flow, Solute flow, Crop growth
Computational outputs	3-day prediction of water demand, Demonstrate impact of different soils on irrigation demand, Analyse leaching potentials
Example	Typical examples are given by Van Dam et al. (2008) for:

1. Field scale water and salinity management

2. Irrigation scheduling

3. Transient drainage conditions

4. Plant growth affected by water and salinity

5. Pesticide leaching to ground water

6. Regional drainage from topp soils towards different surface water systems

7. Optimization of surface water management

8. Effects of soil heterogeneity

Model name SWAT

Acronym **SWAT** Index

2

Web-link http://www.brc.tamus.edu/swat/

Subject Water, catchment

Ecosystem service management Agriculture & apiculture

Description

SWAT is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds.Predict the effect of management decisions on water, sediment, nutrient and pesticide yields with reasonable accuracy on large, ungaged river basins.

Model Operation

•Daily time step-long term simulations

•Basins subdivided to account for differences in soils, land use, crops, topography, weather, etc.

•Basins of several thousand square miles can be studied

•Soil profile can be divided into ten layers

•Basin subdivided into subbasins or grid cells

•Reach routing command language to route and add flows

•Hundreds of cells/subbasins can be simulated in spatially displayed outputs

•Groundwater flow model

•SWAT accepts output from EPIC

Model developer (name, e-mail)	Jeff Arnold jeff.arnold@ars.usda.gov
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Visual Basic
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	
User_friendliness	
User inputs	Weather, surface runoff, return flow, percolation, ET, transmission losses, pond and reservoir storage, crop growth and irrigation, groundwater flow, reach routing, nutrient and pesticide loading, water transfer.
Computational outputs	
Example	1. Was applied intwo test watersheds in the Lahn-Dill-Bergland (north of Giessen, Germany) and the Dietzhölze. 2. Watersheds across the United States have been evaluated recently using SWAT and other models as part of the USDA-ARS Conservation Effects Assessment Program (CEAP). 3. The Finnish test has been chosen the Eurajoki river basin, including Lake Pyhäjärvi.

Model name Surface Water (Hydrology) Study Site Metadata

Acronym **Swssm** Index 5

Web-link http://www.epa.gov/ceampubl/ceamhome.htm

Subject Soil and rock

Water, catchment

Ecosystem service management Agriculture & apiculture

Description

A soil water storage simulation model (SWSSM) was developed to calculate daily soil water storage and corresponding evapotranspiration and deep percolation as a function of water delivery flexibility for a vineyard in California. Adjustment for extremes in weather is not possible. For analysis of quantity and quality problems associated with urban runoff.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon Short-term

Sectoral application area

User_friendliness

User inputs range of irrigation time, furrow inflow rate

Computational outputs

Example

Model name Grapewine growth model, Vimo

Acronym **VIMO** Index 150

Web-link http://www.ipm.ucdavis.edu/DISEASE/DATABASE/grapepowderymildew.html

Subject Water, catchment

Ecosystem service management Agriculture & apiculture

Description

VIMO is a dynamic crop model for dry matter (DM), and nitrogen (N) assimilation and allocation basing on the metabolic-pool model.Photosynthesis and N uptake from the soil are functional response models and are sink-driven. Growth occurs per degree-day above developmental threshold of grapewine. The plant subunits, i.e., the annual populations of fruits, leaves, shoots and roots developing on a perennial frame are age-structured and have distributed developmental times. Their dynamics simulated as a time-invariant distributed delay process with attrition. The seasonal N dynamics is the net result of the processes of new tissue formation with high N concentrations and the degree-day-driven export of N from ageing parts to reserves.

Model purpose

The model forms a basis for analysis in the vineyard ecosystem. It is designed as a research tool for explorative studies in multitrophic systems and can be connected to other models such as insect herbivore models.

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

User inputs

Computational outputs

Example

Models of forestry

Model name BIOMASS

Acronym BIOMASS Index

52

Web-link http://www.wiz.uni-kassel.de/model_db/mdb/biomass.html

Subject Vegetation including fungi

Ecosystem

Ecosystem service management Forestry

Description

Describes canopy net photosynthesis, biomass production and water use of forest stands in relation to weather, nutrition of trees, canopy architecture, soil physical conditions and a number of species specific physiological parameters. The BIOMASS model was used as an ecological risk assessment tool for loblolly pine ecosystems in the southern U.S. It is used now to evaluate potential effects of climate change, CO2 and nitrogen regimes on carbon, water and nutrient fluxes, net primary productivity, and yield. Keywords: canopy, forest, photosynthesis, transpiration, climate change, loblolly pine, process based

Model developer (name, e-mail) r.mcmurtrie@unsw.edu.au

Modelling paradigm

Vertical Complexity

Computing platform Single computer/PDA

Operating system(s) DOS

Modelling language(s) Fortran

Graphical mapping technology Non-GIS

Geographical applicability area

Time horizon Short-term

Sectoral application area Education and learning

User_friendliness Easy-to-use

User inputs

Computational outputs

Example

Model name	Fire Behaivor	
Acronym	**Fire Behaivor**	Index 37
Web-link	http://www.epa.gov/ecopage/upland/oak/oak93/stanton1.htm - MODEL FIRE	
Subject	Ecosystem Socio-environmental	
Ecosystem service management	Forestry	

Description

Predict rate of spread (ROS) and flame length (FL), estimate the area and perimeter of a fire. It uses assumptions of an average worst case scenario.

Model developer (name, e-mail)	Roethermal, Andrews, Byrom, Albini
Modelling paradigm	Simulative prediction
Simulative prediction approach	regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Management Education
User_friendliness	Easy-to-use
User inputs	
Computational outputs	

User inputs spread distance, midflame windspreed

Computational outputs Maximum spotting distance, probability of ignition

Example

Model name Soil-Plant-Atmosphere

Acronym **SPA** Index

188

Web-link http://www.geos.ed.ac.uk/homes/mwilliam/spa.html

Subject Water, catchment

Soil and rock

Ecosystem service management Forestry

Description

The Soil-Plant-Atmosphere model (SPA, Williams et. al 1996) is a process-based model that simulates ecosystem photosynthesis and water balance at fine temporal and spatial scales (30 minute time-step, multiple canopy and soil layers).The detailed soil and rooting routines are described in a follow up paper (Williams et al 2001) .The scale of parametrization (leaf-level) and prediction (canopy level) have been designed to allow the model to diagnose eddy flux data, and to provide a tool for scaling up leaf level processes to canopy and landscape scales. The model has been tested in tropical rain forest (Williams et al 1998), and arctic ecosystems (Williams et al 2000).

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name The Biodiversity Assessment Project

Acronym **BAP toolbox** Index 44

Web-link http://giant.lakeheadu.ca/carisweb/hsm/bap reports/bap reports main.htm

Subject Ecosystem

Ecosystem service management Forestry

Description

Is a suite of indicator models used to assess diverse forest management strategies at three levels of biodiversity: landscape patterns, ecosystem diversity, and habitat supply for specific vertebrate species. Translates a time series of landscape conditions output from landscape models into habitat types that serve as spatial units for ecosystem and the landscape biodiversity (i.e., coarse-filter) assessment.

Model developer (name, e-mail)	Doyon and Duinker
Modelling paradigm	Multi-criteria analysis
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	
Operating system(s)	
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	Management
User_friendliness	
User inputs	forest age
Computational outputs	
Example	Labrador District 19A toolkit & meta-model

Model name Expert system for land use in Hungary

Acronym **Landuse Hungary** Index 99

Web-link http://www.tajhasznalat.hu/

Subject Ecosystem

Ecosystem service management Forestry

Description

The algorithms help to choose the appropriate agri-environmental theme depending on the conditions and environment of an agricultural plot. The output is the evaluation of the desired land use.

Model developer (name, e-mail)	ahorvath@botanika.hu
Modelling paradigm	expert system
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS
Geographical applicability area	Hungary (mainly the Great Hungarian Plan)
Time horizon	Long-term
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	the most important environmental conditions and neighbourhood habitat relations of a given agricultural parcel.
Computational outputs	The evaluation of the selected land use with the following values: (a) the given land use is probably favourable, (b) advantageous, but requires more analyses, (c) risky, regarding ecological sustainability, (e) the given land use must be avoided.
Example	The results of the expert system can be used e.g. in designing the participation of a parcel in agri-environmental programs, or in preparing plans for

Model name MY-X

Acronym **MY-X** Index

97

Web-link http://my-x.hu

Subject Water, catchment

Fauna
Vegetation including fungi
Soil and rock
Ecosystem
Economic
Atmosphere including weather
Social & institutional
Socio-environmental

Ecosystem service management Forestry

Description

http://miau.gau.hu/myx-free/index.php3?x=i0

http://miau.gau.hu/myx-free/index.php3?x=t01

http://miau.gau.hu/myx-free/index_e9.php3?x=e09

The My-X tool is attempting to provide online data mining services for each decision maker instead of being always intuitive/heuristic with the risk of instability and mistake or instead of using well known data mining tools which cause unacceptable cost (through system administration, servers, analysts, licenses, etc.). The first generation of this online tool provides (as a core method) the similarity analysis, which can be interpreted parallel as a special decision tree, an artificial neural network, benchmarking tool, price/performance optimizer or online expert system: (to say) an universal strategy for interpretation of arbitrary phenomena. The similarity analysis needs only one object-attribute-matrix (OAM) as learning pattern. There are a huge number of parameters, in order to be more efficient. Through the provided advising tools you will know about the parameter setting.The following conversation is to determine if all necessary preconditions are met in order to use the COCO-online standard additive procedure. If not, instructions will be given to help decide which procedure to choose. All your

Model developer (name, e-mail) Pitlik (László) pitlik@miau.gau.hu

Modelling paradigm Simulative prediction

Simulative prediction approach	Rule based
	Regression
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
	Unix
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	
Sectoral application area	Research
	Management
	Education and learning
User_friendliness	
User inputs	attribute-matrix (=learning pattern)
Computational outputs	graphs, expert system (combinatorical space)
Example	Monitoring rural development strategies, variant-analysis, forecasting

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Model name	NCSU/APHIS Plant Pest Forecast System	
Acronym	**NAPPFAST**	Index 34
Web-link	http://www.nappfast.org/	
Subject	Vegetation including fungi	
	Atmosphere including weather	
Ecosystem service management	Forestry	
Description		

Internet-based Pest Prediction System for plant pest modelling using georeferenced climatological weather data.

Model developer (name, e-mail)	Dan Borchert, Peg Margosian
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name	Patchworks	
Acronym	**Patchworks**	Index 41
Web-link	http://www.spatial.ca/products/index.html	
Subject	Vegetation including fungi	
	Socio-environmental	
	Economic	

Ecosystem service management Forestry

Description

Is a spatially explicit harvest scheduling model that uses optimization techniques to analyze trade-offs between competing sustainability goals. Functions well at a variety of levels, from policy analysis to strategic and operational planning, combining powerful sensitivity and trade-off analysis functionality. It is an effective decision support and business tool . Can clearly demonstrate trade-offs between competing goals such as timber supply, wildlife habitat availability, road access, efficient silvicultural investment, and other indicators of sustainability.

Model developer (name, e-mail)	info@spatial.ca
Modelling paradigm	Optimization process
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	Labrador District 19A toolkit & meta-model

Model name	PICUS	
Acronym	**PICUS**	Index 58
Web-link	http://www.wabo.boku.ac.at/picus.html?&L=1	
Subject	Vegetation including fungi Fauna	
Ecosystem service management	Forestry	
Description		

- Simulation of forest succession over long time periods under transient climate
- Simulation of equilibrium tree species composition under current climate and climate change scenarios
- Simulation of complex forest management scenarios applicable in multi-species forests under current and changing environmental conditions
- Assessment of carbon-, water-, and nitrogen-cycling in forest ecosystems under current and changing climatic conditions
- Simulation of biotic disturbance regimes (bark beetles) under current and changing climate
- Assessment of the rock fall protection function of forest ecosystems under different management regimes

Model developer (name, e-mail)	Manfred J. Lexer
Modelling paradigm	process-based
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C++
Graphical mapping technology	Non-GIS
Geographical applicability area	Region-specific
Time horizon	Long-term
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name	Sustainable Forest Management Planning Toolkit	
Acronym	**SFM Toolkit**	Index

Web-link	http://www.ecologyandsociety.org/vol12/iss2/art7/
Subject	Ecosystem Economic
Ecosystem service management	Forestry

Description

To assist forest managers in balancing an increasing diversity of resource objectives, we developed a toolkit modelling approach for sustainable forest management (SFM). The approach inserts a meta-modelling strategy into a collaborative modelling framework grounded in adaptive management philosophy that facilitates participation among stakeholders, decision makers, and local domain experts in the meta-model building process. The modelling team works iteratively with each of these groups to define essential questions, identify data resources, and then determine whether available tools can be applied or adapted, or whether new tools can be rapidly created to fit the need. The desired goal of the process is a linked series of domain-specific models (tools) that balances generalized "top-down" models (i.e., scientific models developed without input from the local system) with case-specific customized "bottom-up" models that are driven primarily by local needs. Information flow between models is organized according to vertical (i.e., between scale) and horizontal (i.e., within scale) dimensions. We illustrate our approach within a 2.1 million hectare forest planning district in central Labrador, a forested landscape where social and ecological values receive a higher priority than economic values. However, the focus of this paper is on the process of how SFM modelling tools and concepts can be rapidly assembled and applied in new locations, balancing efficient transfer of science with

Model developer (name, e-mail)	Brian R. Sturtevant bsturtevant@fs.fed.us
Modelling paradigm	EDDS
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Management
User_friendliness	
Example	

Model name Forest Growth Simulator

Acronym **SILVA** Index 49

Web-link
http://www.wwk.forst.tu-muenchen.de/research/methods/modelling/silva/

Subject Fauna

Ecosystem service management Forestry

Description

In the distance-depending individual-tree approach a stand is regarded as a 3-dimensional system of single trees influencing each other mutually. The growth simulator (tree compartments like crowns and stems are modelled) the information available to practical forest management is sufficient as a simulation input.

Model developer (name, e-mail)	Prof. Dr. Hans Pretzsch
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Single computer/PDA
Operating system(s)	Microsoft and Mac
Modelling language(s)	C++
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name Mixed-Species Forest Dynamics Simulator

Acronym **SORTIE** Index 40

Web-link http://www.ecostudies.org/people_sci_canham.html

Subject Vegetation including fungi

Ecosystem

Water, catchment

Ecosystem service management Forestry

Description

A spatially-explicit model of forest dynamics; neighborhood dynamics of forest ecosystems; effects of vertebrate consumers on forest dynamics; effects of hurricanes on temperate and tropical forest dynamics; watershed-scale analyses of variation in lake chemistry; likelihood estimation methods and modelling. This is especially the case following natural and human disturbances. Our understanding of the implications of varying frequency, intensity and pattern of tree death (by either natural agents or logging) on forest community dynamics and ecosystem processes at large-scales and over long time periods is limited.

Model developer (name, e-mail)	Dr. Charles D. Canham
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C++
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	Management
User_friendliness	Easy-to-use

User inputs

Computational outputs

User inputs	list of tree species, densities in size classes
Computational outputs	Basal area, density
Example	1. Labrador District 19A toolkit & meta-model 2. Is a mechanistic, spatially explicit, stochastic model of forests in the north-eastern United States that describes local competition among nine species of trees in terms of empirically derived responses of individuals.

Model name	Nature Conservation Information System (TIR)	
Acronym	**TIR**	Index 100
Web-link	http://geo.kvvm.hu/tir_en/	
Subject	Ecosystem	

Ecosystem service management Forestry

Description

The primary function of the Nature Conservation Information System is to help the work of national parks and conservation authorities by providing a country-wide database and an application developed specifically for the needs of nature conservation professionals. In addition several pieces of information and many maps are produced within the system, which can be used to provide information for the general public.

Model developer (name, e-mail)	vaczi@mail.kvvm.hu
Modelling paradigm	Other
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	
Operating system(s)	
Graphical mapping technology	
Geographical applicability area	Hungary

Time horizon

Sectoral application area Management

User_friendliness

Example Nature Conservation Information System

Model name Physiological Processes Predicting Growth

Acronym **3-PG** Index

46

Web-link http://www.fsl.orst.edu/bevr/model.html

Subject Vegetation including fungi

Fauna

Ecosystem service management Forestry

Description

Calculates the radiant energy absorbed by forest canopies and converts it into biomass production. The efficiency of radiation conversion is modified by the effects of nutrition, soil drought (the model includes continuous calculation of water balance), atmospheric vapour pressure deficits and stand age. The carbon produced by the canopy is allocated to leaves, stems and roots, using dynamic equations that update the state of the system on a monthly time step.

Model developer (name, e-mail) Joe Landsberg and Dick Waring (1997)

Modelling paradigm Simulative prediction

Simulative prediction approach Individual/cell-based (agents)

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s) Excel

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon	Short-term
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	Biomass values: foliage, stems, roots. Max. available soil water, initial stem number, stand age, max stand age, canopy quantum efficiency
Computational outputs	Biomass values: foliage, stems, roots. Max. available soil water, initial stem number, stand age, max stand age, canopy quantum efficiency
Example	

Model name	'FORESEE' - Forest Ecosystems in a Changing Environment	
Acronym	**4C**	Index 58
Web-link	http://www.pik-potsdam.de/~lasch/4c.htm	
Subject	Ecosystem	
	Vegetation including fungi	

Ecosystem service management — Forestry

Description

It describes processes on tree and stand level basing on findings from eco-physiological experiments, long term observations and physiological modelling. The model uses tree and stand level variables to simulate tree species composition, forest structure, leaf area index as well as ecosystem carbon and water balances. Growth and mortality are described for tree cohorts as a group of identical trees concerning their tree characteristics (e.g. stem, leaf, and fine root biomass, height, diameter at breast height and at crown base, species type).

Model developer (name, e-mail)	
Modelling paradigm	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	
Operating system(s)	

Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	
User_friendliness	
Example	Currently the model is parameterised for the five most abundant tree species of Central Europe (beech, Fagus sylvatica L.; Norway spruce, Picea abies L. Karst., Scots pine, Pinus sylvestris L., oaks, Quercus robur L., and Quercus petraea Liebl., and birch

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Model name	a model of growth and matter balance in forest stands	
Acronym	**BALANCE**	Index 108
Web-link	http://www.wwk.forst.tu-muenchen.de/research/methods/modelling/balance/index_html	
Subject	Fauna Ecosystem	

Ecosystem service management Forestry

Description

Is a single-tree model. The main focus is on water, carbon, and nitrogen fluxes, which are used to estimate growth of single trees. The model also represents the changes in stand structure that develop from single tree changes and consequently modifies the internal environmental conditions within the stand. It is used to assess growth and competition under varying environmental conditions and is developed further in order to answer specific questions (parasites, mycorrhiza, reproduction, foliage decline).

Model developer (name, e-mail)	Pretzsch
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use

Computing platform	
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Object Pascal
Graphical mapping technology	
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name	California Conifer Timber Output Simulator	
Acronym	**Cactos**	Index
		165
Web-link	http://www.cnr.berkeley.edu/~wensel/cactos/cactoss.htm	
Subject	Socio-environmental	
Ecosystem service management	Forestry	
Description		

The computer simulator CACTOS is designed for and by the timber industry of northern California with support from the California Department of Forestry and Fire Protection (CDF) and the USDA Forest Service (USFS). The objective is to simulate the changes that take place in the forest stands of the mixed-conifer region of northern California. The changes simulated include the normal growth and mortality as well as the changes due to harvesting operations. The CACTOS System includes the basic "engine" of the system, CACTOS, as well as a series of utility programs to facilite the development of complete stand descriptions for CACTOS and the summary of the results. The CACTOS System is being distributed by Lee C. Wensel. The programs are written in FORTRAN 77 and operate in the DOS enviroment for IBM PC compatible computers. They are intended to be interactive, responding to two-letter commands from the keyboard. However, they can also be operated in "batch" mode.

Model developer (name, e-mail)	Lee C. Wensel
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	DOS
Modelling language(s)	FORTRAN
Graphical mapping technology	Non-GIS
Geographical applicability area	Region-specific
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	stand description, annual precipitation for the water years
Computational outputs	growth coefficients
Example	North-California

Model name CASMOFOR

Acronym **CASMOFOR** Index

106

Web-link http://www.scientia.hu/casmofor

Subject Socio-environmental

Ecosystem service management Forestry

Description

CASMOFOR models the emissions and removals of carbon by forests using standard forest growth information, silvicultural model, and parameters related to carbon fluxes both in the vegetation, as well as dead organic material and soil. Additionally, CASMOFOR also models the costs and benefits of wood production, and allows for an economic analysis of carbon sequestration using afforestations that includes possible revenues from marketing the sequestered carbon in the emissions trading systems.

Model developer (name, e-mail)	som9013@helka.iif.hu
Modelling paradigm	Simulative prediction
Simulative prediction approach	regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Visual Basic MS Excel
Graphical mapping technology	Non-GIS
Geographical applicability area	countries with forest growth models
Time horizon	Long-term
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	simple statistics of a planned afforestation, e.g. area by species and site fertility
Computational outputs	lots of graphs and tables
Example	CASMOFOR allows one to analyse various afforestation scenarios, and compare their carbon sequestration potential and financial costs/benefints with those of other projects to reduce net anthropogenic carbon emissons. CASMOFOR also demonstrates the structure and dynamics of carbon fluxes in forests.

Model name	Crobas

Acronym **Crobas** Index

45

Web-link

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VBS-49R5GX1-2&_user=2728019&_coverDate=12%2F01%2F2003&_alid=1069428742&_rdoc=1&_

Subject Vegetation including fungi

Ecosystem service management Forestry

Description

Whole-tree growth over rotation. Simulation of wood quality. Accounts for the growth of height and volume quasi-independently, in that height and volume are not tied together by an allometric function.

Model developer (name, e-mail) Anniki Mäkelä

Modelling paradigm Simulative prediction

Simulative prediction approach Individual/cell-based (agents)

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s)

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Long-term

Sectoral application area Research (descriptive)

User_friendliness Easy-to-use

User inputs

Computational outputs

User inputs

Computational outputs

Example Forest growth and stand dynamics for the Great Lakes region

Model name Eco-Gene

Acronym **Eco-Gene** Index 28

Web-link http://www.evoltree.eu/index.php/modelling-platform/models/5276?task_view

Subject Vegetation including fungi

Fauna

Ecosystem service management Forestry

Description

Has been developed to study the temporal and spatial dynamics of genetic and demographic processes in a single tree population. EcoGene has been developed with the following tasks in mind:

1 .Analysis of complex population genetic interactions.

2. Hypothesis testing of realized genetic systems in tree populations.

3. Analysis of the effects of human influence on evolutionary processes in tree populations.

4. Deduction of recommendations for sustainable management of genetic resources.

Model developer (name, e-mail) Dr. Antoine Kremer, kremer@pierroton.infra.fr

Modelling paradigm Simulative prediction

Simulative prediction approach

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Internet-linked Servers

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s) Visual Basic

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Long-term

Sectoral application area Management

User_friendliness Expert assistance required

User inputs concerning genetic and spatial data or the age structure of the stand

Computational outputs parameters on genetic variation and genetic differentiation of sub-populations, demography, pollen and seed dispersal and phenology

Example

Model name EFIMOD

Acronym **EFIMOD** Index 54

Web-link www-ai.ijs.si/~ecemeaml/presentations/112-Mikhailov.pdf

Subject Ecosystem

Ecosystem service management Forestry

Description

Comparsion different silvicultural regimes at long-term simulation, analysis of carbon budget, biodiversity and wood production of forest territory.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach Individual/cell-based (agents)

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Long-term

Sectoral application area Research (descriptive)

User_friendliness

User inputs	Air & soil temperature, precipitation, pools of soil organic Matter and nitrogen in forest floor and mineral soil, Potensial growth, specific nitrogen consumption, allocation of biomass between tree organs, tree species composition, number of trees, height, diameter with standard deviation, cutting regimes, type of cutting, rotation length
Computational outputs	Soil temperature and moisture with monthly step, pools of soil organic Matter and nitrogen in organic and mineral soil horizons, tree species composition, number of trees, height, diameter, growing stock, BA, biomass, harvested wood, removal of carbon and nitrogen from the ecosystem
Example	

Model name FEMMA

Acronym **FEMMA** Index

89

Web-link http://www.metla.fi/hanke/3383/femma/index-en.htm

Subject Water, catchment

Ecosystem service management Forestry

Description

To account for the most significant water and N fluxes in forested first-order catchments his, allowed evaluation of the effect of location of clear-cutting on stream water N export. The catchment was simplified into a two-dimensional hill slope extending from the water divide to the outlet. The FEMMA model combined FINNFOR, ROMULN, DEMA calculation tool for assessing catchment water and nitrogen fluxes. Nitrogen is calculated in ammonium, nitrate and dissolved organic nitrogen (DON) fractions.

Model developer (name, e-mail)	Lauren, Ari ari.lauren@metla.fi
Modelling paradigm	Simulative prediction
Simulative prediction approach	Process-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)

Graphical mapping technology		Raster-GIS (grids, pixels)

Geographical applicability area		Universal

Time horizon		Short-term

Sectoral application area		Management

User_friendliness

User inputs

Computational outputs		Runoff, Water balance components for the entire catchment, a forest compartment or a specific location in the catchment, Nitrate load and concentration in the outlet, Ammonium load and concentration in the outlet, DON load and concentration in the outlet, Nitrogen balance.

Example

Model name	FINNFOR

Acronym	**FINNFOR**	Index

56

Web-link	http://www.sci.utu.fi/projects/maantiede/figare/UGS/UGS-83.pdf

Subject	Atmosphere including weather

Fauna

Ecosystem service management	Forestry

Description

The dynamics of the boreal forest ecosystem is directly linked with the climate through photosynthesis, respiration and transpiration. Hydrological and nutrient cycles couple indirectly the dynamics of the ecosystem with climate change through soil process, wich represent the thermal and hydraulic conditions in soil, and the decomposition of litter and humus with the mineralisation of nitrogen. The FinnFor model has been specially developed to predict the impacts of climate change on forest growth and productivity

Model developer (name, e-mail)		seppo.kellomaki@joensuu.fi

Modelling paradigm		Simulative prediction

Simulative prediction approach		regression

Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Management
User_friendliness	
User inputs	Driven by the climatic factors (radiation, temperature, air moisture, CO_2, wind velocity) and soil factors (soil moisture and temperature, water and nitrogen availability).
Computational outputs	
Example	

Model name FORests in a changing CLIMate

Acronym **ForClim** Index 94

Web-link http://www.pik-potsdam.de/research/past/1994-2000/chief/forclim.htm

Subject Vegetation including fungi

Ecosystem service management Forestry

Description

Concept of individualistic, cyclical succession on small patches. Quantitative description of tree population dynamics. Bridging the gap between forest growth and forest succession models. Was designed to incorporate reliable yet simple formulations of climatic influences on ecological processes, using only a minimum number of ecological assumptions. Concept of individualistic, cyclical succession on small patches. Quantitative description of tree population dynamics. Bridging the gap between forest growth and forest succession models.

Model developer (name, e-mail) Bugmann

Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Modula, C#
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	Short-term
Sectoral application area	Research (descriptive)
User_friendliness	
User inputs	monthly means and standard deviation of temperature and precipitation; species specific data, e.g. max. depth, max. height, max. age, drought and shade tolerance, min. winter temperature threshold
Computational outputs	tree species composition, biomass and forest structure across complex gradients of temperature and moisture
Example	Study climate change impacts on protection forests in the Alps and European mountain ranges

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Model name	Forest Growth Model	
Acronym	**FORGRO**	Index 56
Web-link	http://ecobas.org/www-server/rem/mdb/forgro.html	
Subject	Water, catchment Fauna	
Ecosystem service management	Forestry	
Description		

It describes the flow of water, carbon and nutrients in the forest ecosystem. Photosynthesis and respiration, phenology, hydrology (detailed and partly empirical), nutrient cycling (mechanistic), forest growth (detailed and partly empirical), and forest structure development

Model developer (name, e-mail)	g.m.j.mohren@ibn.dlo.nl#http://g.m.j.mohren@i
Modelling paradigm	Simulative prediction
Simulative prediction approach	process-oriented
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Fortran 77
Graphical mapping technology	
Geographical applicability area	
Time horizon	Short-term
Sectoral application area	
User_friendliness	
User inputs	monthly means and standard deviation of temperature and precipitation; species specific data, e.g. max. dbh, max. height, max. age, drought and shade tolerance, min. winter temperature threshold
Computational outputs	
Example	

Model name	The rain forest	
Acronym	**FORMIND**	Index 51
Web-link	http://epic.awi.de/Publications/Koe1998k.pdf	
Subject	Vegetation including fungi	
Ecosystem service management	Forestry	

Description

Disturbances of rain forests, understanding rain forest dynamics, calculation of carbon balances for managed and unmanaged forests.

Model developer (name, e-mail)

Modelling paradigm — Simulative prediction

Simulative prediction approach — Individual/cell-based (agents)

Vertical Complexity — Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s)

Graphical mapping technology — Non-GIS

Geographical applicability area — Region-specific

Time horizon — Long-term

Sectoral application area — Management

User_friendliness

Example

Model name — Rain Forest Growth Simulation Model

Acronym — **FORMIX** — Index 50

Web-link — http://eco.wiz.uni-kassel.de/model_db/mdb/formix.html

Subject — Ecosystem

Ecosystem service management — Forestry

Description

A dynamic simulation model for the growth of tropical rain forest. For each species group the model calculates biomass and tree number in five distinct canopy layers. This model cannot account for the effects of climate change; photosynthesis is empircally based: and model does not simulate soil water balance, soil carbon fluxes and heterotrophic respiration. The model has proved usefull for studies on allometry and forest management.

Model developer (name, e-mail)	Andreas Huth huth@usf.uni-kassel.de
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	DOS
Modelling language(s)	Turbo Pascal, C
Graphical mapping technology	Non-GIS
Geographical applicability area	Region-specific
Time horizon	Long-term
Sectoral application area	
User_friendliness	
Example	1. FORMIX was applied in combination with a geographic information system. The study was carried out for the 55 084 ha of the Deramakot Forest Reserve in Canada.

Model name Forest Vegetaion Simulator

Acronym **FVS -TWIGS** Index 48

Web-link http://www.fs.fed.us/fmsc/fvs/index.htm

Subject Vegetation including fungi

Ecosystem service management Forestry

Description

Is an individual-tree, distance-independent growth and yield model. Simulate growth and yield for major forest tree species, forest types, and stand conditions and composition to determine the suitability of stands for wildlife habitats and to predict losses from fire and insect outbreaks. Model predict relatively small landscapes.

Model developer (name, e-mail) wo_ftcol_fmsc@fs.fed.us

Modelling paradigm	Simulative prediction
Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	
Geographical applicability area	
Time horizon	
Sectoral application area	
User_friendliness	
User inputs	forest inventory data, stand attributes, a list of individual tree records
Computational outputs	
Example	

Model name	LandClim	
Acronym	**LandClim**	Index 64
Web-link	http://e-collection.ethbib.ethz.ch/eserv/eth:27405/eth-27405-02.pdf	
Subject	Vegetation including fungi	
Ecosystem service management	Forestry	
Description		

Analyses the effect of topography, climate and land use on forest structure and dynamics. A particular focus is on large-scale natural disturbances like fire, wind throw, management. Modeled processes sensitive to climate. Spatially explicit (grid cell 30*30 m). LandClim calculates soil moisture availability using a simple bucket model. LandClim is based on an existing model (LANDIS), which incorporates a range of large-scale processes such as seed dispersal, wind and fire disturbances and harvesting, which dynamically interact with forest vegetation.

Model developer (name, e-mail)

Modelling paradigm | Optimization process

Vertical Complexity | Software tool, packaging one or more formulae for practical use

Computing platform | Single computer/PDA

Operating system(s) | Microsoft (Windows, Silverlight, .net etc)

Graphical mapping technology | Raster-GIS (grids, pixels)

Geographical applicability area | Region-specific

Time horizon | Long-term

Sectoral application area | Management

Research (descriptive)

User_friendliness

Example | lake sediment paleobotanical reconstrions from Swiss Central Alps (Henne, 2008)

Model name Forest landscape disturbance, Management, and Succession

Acronym **LANDIS** Index 63

Web-link http://e-collection.ethbib.ethz.ch/eserv/eth:27405/eth-27405-02.pdf

Subject Ecosystem

Ecosystem service management Forestry

Description

In general simulate broad-scale (>105 ha) landscape dynamics, including succession, disturbance, seed dispersal, forest management, and climate change effects. Landis would estimate fire risk by accounting for the interactions among vegetation-management treatments, forest succession, natural disturbance, and hunamcaused ignitoins, cannot predict the expansion of human populations through time.

Model developer (name, e-mail) heh@missouri.edu

Modelling paradigm Simulative prediction

Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	
Time horizon	Long-term
Sectoral application area	
User_friendliness	
Example	

Model name LANDIS-II

Acronym **LANDIS-II** Index 40

Web-link http://www.landis-ii.org/

Subject Vegetation including fungi

Ecosystem

Ecosystem service management Forestry

Description

Using to investigate the strength of interactions between forest succession, harvesting, and fire disturbance processes. Model integrate ecosystem process, aboveground living biomass, and dead biomass for landscape change; quantify the influence of multiple disturbances on aboveground biomass and species composition and evaluate model results and conduct a sensitivity analysis of the model parameters.

Model developer (name, e-mail)	Scheller and Mladenoff
Modelling paradigm	Simulative prediction
Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for

	practical use
Computing platform	Distributed Processing (e.g. GRID)
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C#
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	
Time horizon	Long-term
Sectoral application area	
User_friendliness	
Example	1. Labrador District 19A toolkit & meta-model

Model name	Structural Analysis of Forest Stands	
Acronym	**LIGNUM**	Index 60
Web-link	http://www.metla.fi/metinfo/kasvu/lignum/index-en.htm	
Subject	Vegetation including fungi	
Ecosystem service management	Forestry	

Description

LIGNUM model for coniferous trees. The model LIGNUM presents coniferous and deciduous trees with simple structural units called tree segment (TS), branching point (BP) and bud(B) that have close likeness to real tree parts. The main functioning unit is the cylindrical tree segment consisting of heartwood, sapwood and foliage. Figure Ia introduces a model tree for conifers and Figure Ib simulated Scots pine. Figure IIa reveals a model tree with explicit leaves for deciduous species and Figure IIb is a simulated sugar maple.

Model developer (name, e-mail)	risto.sievanen@metla.fi
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA

Operating system(s)	Unix, Linux or other Unix-like
Modelling language(s)	C++
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	
User inputs	Branching and the local light conditions, the effect of slowing down the fluid and nutrient flow in the branches of the tree. The foliage mass of the mother tree segment
Computational outputs	
Example	

Model name LINKAGES

Acronym **LINKAGES** Index 36

Web-link http://www.esd.ornl.gov/~wmp/LINKAGES/doc/ornl-9519.pdf

Subject Socio-environmental

Ecosystem service management Forestry

Description

Simulates individual tree establishment, growth, competition, and mortality as a function of soil water, nutrient dynamics, and monthly average temperature and precipitation. Used to estimate the probability of tree establishment for tree species in two different ecozones.

Model developer (name, e-mail)	Pastor and Post
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for

practical use

Computing platform	Single computer/PDA
Operating system(s)	DOS
Modelling language(s)	Fortran
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	Long-term
Sectoral application area	Management
User_friendliness	
User inputs	Incoming sunlight, soil organic matte, nitrogen contens, monthly mean rainfall, monthly mean temperature, nitrogen availability, tree growth
Computational outputs	
Example	

Model name	LPJ Dynamic Global Vegetation Model	
Acronym	**LPJ DGVM**	Index 153
Web-link	http://www.pik-potsdam.de/research/cooperations/lpjweb	
Subject	Water, catchment Soil and rock	
Ecosystem service management	Forestry	

Description

LPJ is a dynamic global simulation model of vegetation biogeography and vegetation/soil biogeochemistry. Taking climate, soil and atmospheric information as input, it dynamically computes spatially explicit transient vegetation composition in terms of plant functional groups, and their associated carbon and water budgets. LPJmL additionally simulates the carbon and water budgets of agricultural lands and of land use change; it is being extended to include forestry. It takes as inputs land use and land management data.

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity | Software tool, packaging one or more formulae for practical use

Computing platform | Internet-linked Servers

Operating system(s) | Microsoft (Windows, Silverlight, .net etc)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name L-VIS

Acronym **L-VIS** Index 70

Web-link http://www.wwk.forst.tu-muenchen.de/info/vis/3D_html

Subject Visualization

Vegetation including fungi

Ecosystem service management Forestry

Description

L-Vis uses the individual-tree dimensions (SILVA 2.0), tree positions and distribution of regeneration from the simulation results of individual-tree models. These individual-tree models perform actual simulations of the long-term forest development at the stand, estate and landscape level based on inventory data, and provide the data for landscape scale visualisation. The forest dynamics among the sample points is completed by structural interpolation routines. Forest landscape visualisation software.

Model developer (name, e-mail)

Modelling paradigm Optimization process

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	Long-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	Bürgerwald in Traunstein mixed stand of Norway spruce and European beech

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Model name	PnET	
Acronym	**PnET**	Index
		46
Web-link	http://www.pnet.sr.unh.edu/	
Subject	Ecosystem	
Ecosystem service management	Forestry	

Description

Is a suite of three nested computer models which provide a modular approach to simulating the carbon, water and nitrogen dynamics of forest ecosystems. For regional productivity and water balances, PnET has been run for each

pixel of the 1 km resolution GIS data base.

Model developer (name, e-mail)	Aber and Federer
Modelling paradigm	Simulative prediction
Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for

	practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Visual Basic
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	
Time horizon	Long-term
Sectoral application area	
User_friendliness	
Example	1. To run PnET regionally to predict potential forest productivity under current and double CO2 conditions for Ireland. 2. PnET has been used in conjunction with estimates of canopy chemistry obtained by high resolution remote sensing for the Prospect Hill tract at Harvard Forest .

Model name	Riparian Ecosystem Management Model	
Acronym	**REMM**	Index
		173
Web-link	http://www.tifton.uga.edu/remmwww/	
Subject	Water, catchment	
	Ecosystem	
Ecosystem service management	Forestry	
Description		

The Riparian Ecosystem Management Model (REMM) is a computer simulation model. REMM is used to simulate hydrology, nutrient dynamics and plant growth for land areas between the edge of fields and a water body. Output from REMM will allow designers to develop buffer systems to help control non-point source pollution. REMM simulates hydrologic, carbon and nutrient cycling, and plant growth processes in riparian forest systems on a daily time step (Lowrance et.al., 1998). The results of the simulations are the model output, which are the operational characteristics of riparian buffer systems.

Model developer (name, e-mail)	Randy Williams randy@tifton.cpes.peachnet.edu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C++
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use
User inputs	weather, itter and three soil layers, plant growth that occur in each zone, vertical and horizontal subsurface, carbon and nutrient dynamics
Computational outputs	characteristics of riparian buffer systems
Example	

Model name	SIERRA	
Acronym	**SIERRA**	Index 62
Web-link	http://www.evenor-tech.com/microleis/microlei/microlei.aspx	
Subject	Fauna	
	Socio-environmental	
Ecosystem service management	Forestry	
Description		

Sierra comprises two modules "Description of forest species", detailing the edaphoclimatic requirements of 22 typical Mediterranean forest species; and an evaluation module, for selecting the best species for the land-unit evaluated.

Model developer (name, e-mail)	Prof. D. de la Rosa
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	
User inputs	Site-, soil-, crop-, climate-related variables
Computational outputs	For all the species analyzed, positive results are listed on-screen as species appropriate for that site
Example	

Model name	Silvisio	
Acronym	**Silvisio**	Index 72
Web-link	http://www.zib.de/visual/projects/silvisio/silvisio.frameset.en.html	
Subject	Vegetation including fungi visualization	
Ecosystem service management	Forestry	
Description		

Photorealistic visualization of landscapes enables intuitive presentation of complex interrelations in current and future use of forests in different scales from 1:1 to ordnance map. The Lenné3D system will be enhanced to allow participatory development of mission statements. Thinking ahead of possible forest trends by policy makers will be eased by simulation and visualization. It is going to be evaluated whether currently available planning instruments are capable of visualization of mission statements and how these instruments have to be modified.

Used models Silva and Lenné3D.

Model developer (name, e-mail)	silvisio@zalf.de
Modelling paradigm	Other
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	
Example	

Model name	TREEDYN3	
Acronym	**TREEDYN3**	Index 54
Web-link	http://www.helmholtz-muenchen.de/	
Subject	Vegetation including fungi	
	Soil and rock	
Ecosystem service management	Forestry	
Description		

TREEDYN3 is a process model for tree growth, carbon and nitrogen dynamics in a single-species, even-aged forest stand. The tree/soil system is described by a set on nonlinear ordinary differential equations for the state variables: tree number, base diameter, tree height, leaf mass, fine root mass, fruit biomass, assimilate, carbon and nitrogen in litter, soil and organic matter, and plant available nitrogen. It includes explicit formulations of all relevant ecophysiological processes such as computation of radiation as a function of seasonal time and daytime, light attenuation in the canopy, and canopy photoproduction as a function of latitude, seasonal time and daytime, respiration of all parts, assimilate allocation, increment formation, nitrogen fixation, mineralization, humification and leaching, forest management, temperature effects on respiration.TREEDYN3 was parametrized for European tree species (Picea abies, Pinus sylvestris, Pinus pinaster, Quercus ilex, Fagus sylvatica) and applied on a number of sites throughout Europe to questions of long-term impacts of climate change on carbon dynamics and forest stand growth (EU-project LTEEF). The nitrogen fertilization effect on stand growth caused by increased nitrogen deposition was evaluated for the Solling F1-site.

Model developer (name, e-mail)	
Modelling paradigm	ordinary differential equations
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Unix, Linux or other Unix-like
Modelling language(s)	Pascal, C++
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Research (descriptive)
User_friendliness	
User inputs	tree number, base diameter, tree height, wood biomass, nitrogen in wood, leaf mass, fine root mass, fruit biomass, assimilate, carbon and nitrogen in litter, carbon and nitrogen in soil organic matter, and plant-available nitrogen.
Computational outputs	crown projection area
Example	

Model name TREEVIEW

Acronym **TREEVIEW** Index

73

Web-link http://www.wwk.forst.tu-muenchen.de/info/vis/3D_html

Subject Vegetation including fungi

Ecosystem service management Forestry

Description

Interactive visualisation of forest stands. Displays geometrically modelled trees with same geometry as the virtual objects in the individual-tree simulation models.

Model developer (name, e-mail) Seifert

Modelling paradigm Optimization process

Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Graphical mapping technology Non-GIS

Geographical applicability area

Time horizon Not specified

Sectoral application area Management

Research (descriptive)

User_frendliness Easy-to-use

User inputs

Computational outputs

Example

Models of recreational site management

Model name MY-X

Acronym **MY-X** Index

97

Web-link http://my-x.hu

Subject Water, catchment

Fauna

Vegetation including fungi
Soil and rock
Ecosystem
Economic
Atmosphere including weather
Social & institutional
Socio-environmental

Ecosystem service management	Amenity areas

Description

http://miau.gau.hu/myx-free/index.php3?x=i0

http://miau.gau.hu/myx-free/index.php3?x=t01

http://miau.gau.hu/myx-free/index_e9.php3?x=e09

The My-X tool is attempting to provide online data mining services for each decision maker instead of being always intuitive/heuristic with the risk of instability and mistake or instead of using well known data mining tools which cause unacceptable cost (through system administration, servers, analysts, licenses, etc.). The first generation of this online tool provides (as a core method) the similarity analysis, which can be interpreted parallel as a special decision tree, an artificial neural network, benchmarking tool, price/performance optimizer or online expert system: (to say) an universal strategy for interpretation of arbitrary phenomena. The similarity analysis needs only one object-attribute-matrix (OAM) as learning pattern. There are a huge number of parameters, in order to be more efficient. Through the provided advising tools you will know about the parameter setting. The following conversation is to determine if all necessary preconditions are met in order to use the COCO-online standard additive procedure. If not, instructions will be given to help decide which procedure to choose. All your

Model developer (name, e-mail)	Pitlik (László) pitlik@miau.gau.hu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule based
	Regression
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
	Unix
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal

Time horizon	
Sectoral application area	Research
	Management
	Education and learning
User_friendliness	
User inputs	attribute-matrix (=learning pattern)
Computational outputs	graphs, expert system (combinatorical space)
Example	Monitoring rural development strategies, variant-analysis, forecasting

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Model name DRAINMOD

Acronym **DRAINMOD** Index 16

Web-link http://www.bae.ncsu.edu/soil_water/drainmod/

Subject Water, catchment

Traffic

Ecosystem service management Amenity areas

Description

The model simulates the hydrology of poorly drained, high water table soils on an hour-by-hour, day-by-day basis for long periods of climatological record (e.g. 50 years). The model predicts the effects of drainage and associated water management practices on water table depths, the soil water regime and crop yields. Predict the best trafficability period. This Is a field-scale water management simulation model.

Model developer (name, e-mail)	wayne_skaggs@ncsu.edu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Richards equation
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)	Visual Basic
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	Soil properties, crop inputs, water management parameters, climatic input data
Computational outputs	
Example	Southeast Purdue Agricultural Center

Model name Agricultural Household Model

Acronym **GAMS** Index

144

Web-link http://www.reap.ucdavis.edu/research/Agricultural.pdf

Subject Economic

Ecosystem service management Amenity areas

Description

This model to explore household-level impacts of agricultural policy changes on production and incomes under alternative rural-market scenarios. Household-farm models are a useful tool to study how household-specific transaction costs shape the impacts of exogenous policy and market changes in rural areas. We use the model to explore household-level impacts of agricultural policy changes under the North American Free-Trade Agreement (NAFTA) on production and incomes under alternative rural-market scenarios. A model was needed to explain the economic behavior of: (1) the net-surplus producing family farm, typical of small owner-operated farms of medium productivity; (2) the subsistence and sub-subsistence household farm, typical of small-scale, low productivity agriculture, frequently operating under marginal conditions and incomplete markets; (3) small-scale renter and sharecropper farms; and (4) the owner-operated commercial farms producing food for both domestic consumption and agro-industry and export markets.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction

Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	Not specified
Sectoral application area	Management
	Research (descriptive)
User_friendliness	
User inputs	goods
Computational outputs	full profit
Example	Mexican village

Model name Recreation Behaviour Simulator

Acronym **RBSim** Index 80

Web-link http://www.srnr.arizona.edu/~gimblett/rbsim.html

Subject Social & institutional

Ecosystem service management Amenity areas

Description

RBSim used real-world geographic features (including topography, vegetation and roads) to evaluate the recreational use. Specifically, current hiking, bike, and off-road trail paths were mapped in a GIS to aid management decisions of environmental protection and enhance recreational user experiences.

Model developer (name, e-mail)	H. Randy Gimblett
Modelling paradigm	Simulative prediction

Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Region-specific
Time horizon	Not specified
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	Visitor arrival, trip itineraries, and duration of stay at destinations, information about travel mode characteristics (for example, foot, car, bus, or horse), travel speed, and a trip itinerary.
Computational outputs	Use density, encounter, and queuing time measures. To describe the distribution of use across a large complex of backcountry trails and campsites.
Example	

Model name	Spatial Planning Optimisation Model	
Acronym	**SPOM**	Index 74
Web-link	http://www2.uah.es/josemrey/Reprints/Purves_etal_oaks_07.pdf	
Subject	Ecosystem	
Ecosystem service management	Amenity areas	

Description

To determine the optimal spatial planning for business parks and industrial zones, based on (environmental) criteria and restrictions. Describe metapopulation dynamics, habitat patch area, connectivity. This approach gives a parsimonious modelling framework that is capable of capturing interactions between environmental forcing and population dynamics; provides a means for identifying key biotic–abiotic linkages; and yields a framework for predicting potential effects of environmental change on vegetation dynamics, including, for example, climate change, habitat loss, and fragmentation.

Model developer (name, e-mail)	pcj@syntens.nl
Modelling paradigm	Optimization process
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	
Example	1. Environmental heterogeneity, bird-mediated directed dispersal, and oak woodland dynamics in Mediterranean Spain. 2. A Regional Model Of The Sub-polar North Atlantic

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Model name Wilderness

Acronym **Wilderness** Index 86

Web-link
http://www.wilderness.net/library/documents/aug03_van_wagtendonk.pdf

Subject Social & institutional

Ecosystem service management Amenity areas

Description

A travel simulation model. Shows the relationship between the natural, undisturbed purity of a wilderness and the human influence that affects it. A travel simulation model developed to analyze the effects of alternative management practices on the quality of low-density recreation experiences. The model represents the first attempt to represent the travel behavior of wilderness recreationists in a format consistent with the analysis of management policy. The model can accommodate large scale areas and has been applied to the Spanish Peaks Area in Montana and the Desolation Wilderness in California.

Model developer (name, e-mail)	V. Kerry Smith
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	Management
User_friendliness	
Example	Has been applied to the Spanish Peaks Area in Montana and the Desolation Wilderness in California.

Model name	Wilderness use simulation model	
Acronym	**WUSM**	Index 88
Web-link	http://adsabs.harvard.edu/abs/1986EnMan..10..367U	
Subject	visualization Social & institutional	
Ecosystem service management	Amenity areas	
Description		

Model (WUSM) for peak season boating. To select trip itineraries for inclusion. By randomizing itinerary schedules based on probabilities developed from actual use of sites by canyon visitors.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	
Sectoral application area	Management
User_friendliness	
Example	Applied the Colorado River through Grand Canyon National Park, USA

Model name	Simulation of Disturbance Activities	
Acronym	**SODA**	Index 184
Web-link	http://estebanfj.bio.purdue.edu/papers/ECOCOM157.pdf	
Subject	Social & institutional Fauna	

Ecosystem service management	Hunting & angling
Description	

Simulation of Disturbance Activities (SODA) is aspatially explicit individual-based model designed as a flexible and transferable practicaltool to explore the effects of spatial and temporal patterns of anthropogenic disturbance onwildlife.

Model developer (name, e-mail)	Victoria J. Bennett
Modelling paradigm	Simulative prediction

Simulative prediction approach	
Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	
Operating system(s)	
Graphical mapping technology	
Geographical applicability area	Universal
Time horizon	
Sectoral application area	Management
User_friendliness	
Example	

Model name	Recreation Behaviour Simulator	
Acronym	**RBSim**	Index 81
Web-link	http://www.srnr.arizona.edu/~gimblett/rbsim.html	
Subject	Social & institutional	
Ecosystem service management	Tourism and access-based recreation	

Description

RBSim used real-world geographic features (including topography, vegetation and roads) to evaluate the recreational use. Specifically, current hiking, bike, and off-road trail paths were mapped in a GIS to aid management decisions of environmental protection and enhance recreational user experiences.

Model developer (name, e-mail)	H. Randy Gimblett
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA

Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Region-specific
Time horizon	Not specified
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	Visitor arrival, trip itineraries, and duration of stay at destinations, information about travel mode characteristics (for example, foot, car, bus, or horse), travel speed, and a trip itinerary.
Computational outputs	Use density, encounter, and queuing time measures. To describe the distribution of use across a large complex of backcountry trails and campsites.
Example	

Model name Simulation of Disturbance Activities

Acronym **SODA** Index 209

Web-link http://estebanfj.bio.purdue.edu/papers/ECOCOM157.pdf

Subject Social & institutional
Fauna

Ecosystem service management Tourism and access-based recreation

Description

Simulation of Disturbance Activities (SODA) is aspatially explicit individual-based model designed as a flexible and transferable practicaltool to explore the effects of spatial and temporal patterns of anthropogenic disturbance onwildlife.

Model developer (name, e-mail)	Victoria J. Bennett
Modelling paradigm	Simulative prediction
Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for

practical use

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area Universal

Time horizon

Sectoral application area Management

User_friendliness

Example

Model name TourSim

Acronym **TourSim** Index 81

Web-link http://toursim.wordpress.com/scenarios/

Subject Socio-environmental

Ecosystem service management Tourism and access-based recreation

Description

TourSim uses tourist preference data. This survey has a wider range of accommodation and activity options. Each destination has a maximum capacity for visits, based on occupancy data provided by a mandatory reporting program. Every month, the destination examines the number of tourists who have visited in that month.

Model developer (name, e-mail) Peter Johnson

Modelling paradigm Simulative prediction

Simulative prediction approach regression

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Internet-linked Servers

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area Region-specific

Time horizon Not specified

Sectoral application area Management

Education

User_friendliness Easy-to-use

User inputs

Computational outputs

Example

Model name Wilderness

Acronym **Wilderness** Index

87

Web-link
http://www.wilderness.net/library/documents/aug03_van_wagtendonk.pdf

Subject Social & institutional

Ecosystem service management Tourism and access-based recreation

Description

A travel simulation model. Shows the relatinship between the natural, undisturbed purity of a wilderness and the human influence that affects it.A travel simulation model developed to analyze the effects of alternative management practices on the quality of low-density recreation experiences. The model represents the first attempt to represent the travel behavior of wilderness recreationists in a format consistent with the analysis of management policy. The model can accommodate large scale areas and has been applied to the Spanish Peaks Area in Montana and the Desolation Wilderness in California.

Model developer (name, e-mail) V. Kerry Smith

Modelling paradigm Simulative prediction

Simulative prediction approach Individual/cell-based (agents)

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Long-term

Sectoral application area Management

User_friendliness

Example Has been applied to the Spanish Peaks Area in Montana and the Desolation Wilderness in California.

Model name Wilderness use simulation model

Acronym **WUSM** Index

88

Web-link http://adsabs.harvard.edu/abs/1986EnMan..10..367U

Subject visualization

Social & institutional

Ecosystem service management Tourism and access-based recreation

Description

Model (WUSM) for peak season boating. To select trip itineraries for inclusion. By randomizing itinerary schedules based on probabilities developed from actual use of sites by canyon visitors.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach Individual/cell-based (agents)

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	
Sectoral application area	Management
User_friendliness	
Example	Applied the Colorado River through Grand Canyon National Park, USA

Model name Nature Conservation Information System (TIR)

Acronym **TIR** Index

100

Web-link http://geo.kvvm.hu/tir_en/

Subject Ecosystem

Ecosystem service management Tourism and access-based recreation

Description

The primary function of the Nature Conservation Information System is to help the work of national parks and

conservation authorities by providing a country-wide database and an application developed specifically for the needs of nature conservation professionals. In addition several pieces of information and many maps are produced within the system, which can be used to provide information for the general public.

Model developer (name, e-mail) vaczi@mail.kvvm.hu

Modelling paradigm Other

Vertical Complexity Decision support system, organizing or enabling several modelling tools

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area Hungary

Time horizon

Sectoral application area Management

User_friendliness

Example Nature Conservation Information System

Model name The plant architectural model

Acronym **AMAP/Imagis** Index 68

Web-link http://umramap.cirad.fr/amap2/logiciels_amap/index.php?page=amapsim

Subject Ecosystem

Ecosystem service management Urban planning

Description

IMAGIS is an interface between the 2 D world of plans and the 3 D world of perspectives. It implements a set of procedures specifically designed to transform landscape forms described in a GIS quite synthetically by 2 D entities, into much more elaborate objects in a 3 D space. It is intended for creating broad landscape models, from which photorealistic images can be computed with Atelier de Modélisation de l'Architecture des Plantes (AMAP) software. AMAP is a modelling workshop allowing users to generate and visualize a large number of plant models at various growth stages. AMAP was created from the outset for the needs of agronomists who seek to simulate very accurately the architecture and growth behavior of plants, in a natural or a designed environment. It is now quite established in the realm of landscape architecture. IMAGIS is aiming at a different community of users: the planning and GIS organizations who need to visualize regional development plans for impact assessment, communication and decision-making purposes. Although, it may be applied in a wide variety of contexts, its built-in features makes it particularly suitable for suburban planning.

Model developer (name, e-mail) amapsim@cirad.fr

Modelling paradigm Simulative prediction

Simulative prediction approach

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s) Unix, Linux or other Unix-like

Graphical mapping technology Vector-GIS (polygons, lines, points)

Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	Management
	Research (descriptive)
User_friendliness	
User inputs	Scatterers density, Geometric description, Surface roughness, Moisture (ground, vegetation), Acquisition parameters (f,p,i)
Computational outputs	backscatter values, scattering mechanisms, contribution of scatterers
Example	This approach is illustrated on a simple forest ecosystem, an Austrian pine forest over hilly terrain in southern of France.

Models of Aquaculture and commercial fishing

Model name	Bioaccumulation and Aquatic System Simulator	
Acronym	**BASS**	Index
		160
Web-link	http://www.epa.gov/athens/staff/members/barbermahlonc/index.html	
Subject	Water, catchment	
Ecosystem service management	Aquaculture & commercial fishing	
Description		

Craig Barber is the principal developer of the Bioaccumulation and Aquatic System Simulator (BASS) which is a Fortran 95 simulation model that predicts the population and bioaccumulation dynamics of age-structured fish assemblages which are exposed to hydrophobic organic pollutants and class B and borderline metals that complex with sulfhydryl groups (e.g., cadmium, copper, lead, mercury, nickel, silver, and zinc). BASS's bioaccumulation algorithms are based on diffusion kinetics and are coupled to a process-based model for the growth of individual fish. The model's exchange algorithms consider both biological attributes of fishes and physico-chemical properties of the chemicals of concern that determine diffusive exchange across gill membranes and intestinal mucosa. Biological characteristics used by the model include the fish's gill morphometry, feeding and growth rate, and proximate composition (i.e., its fractional aqueous, lipid, and structural organic content). Relevant physico-chemical properties are the chemical's aqueous diffusivity, n-octanol/water partition coefficient (Kow), and, for metals, binding coefficients to proteins and other organic matter. bass simulates the growth of individual fish using a standard mass balance, bioenergetic model (i.e., growth = ingestion - egestion - respiration - specific dynamic action - excretion). A fish's realized ingestion is calculated from its maximum consumption rate adjusted for the availability of prey of the appropriate size and taxonomy. The community's food web is specified by defining one or more foraging classes for each fish species based on either its body weight, body length, or age. The dietary composition of each of these feeding classes is specified as a combination of benthos, incidental terrestrial insects, periphyton/attached algae, phytoplankton, zooplankton, and one or more fish species. Population dynamics are generated by predatory mortalities defined by community's food web and standing stocks, size dependent physiological mortality rates, the maximum longevity of species, and toxicological responses to chemical exposures. The model's temporal and spatial scales of resolution are a day and a hectare, respectively. Currently, BASS ignores the migration of fish into and out of the simulated hectare.

BASS is currently being used to investigate methylmercury bioaccumulation in the Florida Everglades and to predict population and community dimensions of "fish health" for a regional analysis of the ecological sustainability of the Albemarle-Pamlico drainage basin in North Caorolina and Virginia.

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name Raceway design and simulation system

Acronym **RDSS** Index 102

Web-link

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T4C-4SYTC8F-1&_user=2728019&_coverDate=11/30/2008&_alid=1069448178&_rdoc=1&_fmt=hig

Subject	Water, catchment Fauna Economic
Ecosystem service management	Aquaculture & commercial fishing

Description

The program simulates the conditions in a system of multiple tanks that may be arranged in sets of parallel raceways with serial water flow. The user may specify the use of overflow weirs or customized oxygen injection points in order to reoxygenate the water flow from succeeding tanks in each raceway. During the course of the simulation, the user may specify the size, number, location, and price of any new fish introduced into any raceway tank.

Model developer (name, e-mail)	Richard Turton
Modelling paradigm	Simulative prediction
Simulative prediction approach	regression
Vertical Complexity	
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	VB MS Excel
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	Short-term
Sectoral application area	Research (descriptive) Management
User_friendliness	Easy-to-use
User inputs	Water temperature, flowrate, dissolved oxygen, pH, total ammonia nitrogen, and salinity. Stocking information, the costs of food, the purchase cost of fish, and the revenue from the sale of fish are also tracked
Computational outputs	Fish growth and mortality

Example

Model name Farm Aquaculture Resource Management Model

Acronym **FARM** Index 82

Web-link http://www.farmscale.org

Subject Fauna

Ecosystem

Ecosystem service management Aquaculture & commercial fishing

Description

Model is for shellfish farms (without the use of artificial food) in coastal and estuarine waters. The model runs as a web-based client-server application with a simple interface, hiding complex internal processing which includes transport equations, shellfish individual growth for several species, population dynamics and dissolved oxygen balance.

Model developer (name, e-mail) info@longline.co.uk

Modelling paradigm

Vertical Complexity Decision support system, organizing or enabling several modelling tools

Computing platform Internet-linked Servers

Operating system(s)

Graphical mapping technology Non-GIS

Geographical applicability area

Time horizon Not specified

Sectoral application area Management

User_friendliness

User inputs The water current is flowing from left to right, and transports suspended particles (TPM). This contains the natural food supply: algae - chlorophyll a (Chl a), and organic detritus - particulate organic matter (POM).The yield of the farm based on (a) food supply; (b) farm size; (c) shellfish density; and (d)

	environmental parameters.
Computational outputs	(a) Chlorophyll and dissolved oxygen concentration;
	(b) Number of adult (harvestable) shellfish;
	(c) Adult shellfish biomass
Example	Blue mussel, Pacific oyster and Chinese scallop

Model name	MY-X	
Acronym	**MY-X**	Index
		97
Web-link	http://my-x.hu	
Subject	Water, catchment	
	Fauna Vegetation including fungi Soil and rock Ecosystem Economic Atmosphere including weather Social & institutional Socio-environmental	

Ecosystem service management Aquaculture & commercial fishing

Description

http://miau.gau.hu/myx-free/index.php3?x=i0

http://miau.gau.hu/myx-free/index.php3?x=t01

http://miau.gau.hu/myx-free/index_e9.php3?x=e09

The My-X tool is attempting to provide online data mining services for each decision maker instead of being always intuitive/heuristic with the risk of instability and mistake or instead of using well known data mining tools which cause unacceptable cost (through system administration, servers, analysts, licenses, etc.). The first generation of this online tool provides (as a core method) the similarity analysis, which can be interpreted parallel as a special decision tree, an artificial neural network, benchmarking tool, price/performance optimizer or online expert system: (to say) an universal strategy for interpretation of arbitrary phenomena. The similarity analysis needs only one object-attribute-matrix (OAM) as learning pattern. There are a huge number of parameters, in order to be more efficient. Through the provided advising tools you will know about the parameter setting.The following conversation is to determine if all necessary preconditions are met in order to use the COCO-online standard additive procedure. If not, instructions will be given to help decide which procedure to choose. All your

Model developer (name, e-mail)	Pitlik (László) pitlik@miau.gau.hu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule based
	Regression
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
	Unix
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	
Sectoral application area	Research
	Management
	Education and learning
User_friendliness	
User inputs	attribute-matrix (=learning pattern)
Computational outputs	graphs, expert system (combinatorical space)
Example	Monitoring rural development strategies, variant-analysis, forecasting

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Model name Technical and decision making support system for sustainable water management

Acronym **STEDIWAT** Index

152

Web-link omicron.ch.tuiasi.ro/EEMJ/pdfs/vol8/no4/14_STEDIWAT.pdf

Subject

Ecosystem service management Aquaculture & commercial fishing

Description

The activities of the STEDIWAT Project rely on a multidisciplinary and integrated approach that focuseseon:• integrated issues related to the water cycle, supply, treatment, use and reuse at the level of stakeholders considering their interaction at the level of four basins in Romania (Prut, Banat, Arges-Vedea, Olt);• development of a complex support system that will facilitate decision-making interaction and adaptive management at the level of the stakeholder but also on the level of the system as a whole (management of Complexity of decision ontexts specific to IWRM).• it facilitates of knowledge transfer, training, communication, dissemination and collaboration between the scientific groups, decision makers and other stakeholders, considering also the actual "water demand and supply" pressures and behaviors of different stakeholders involved.

Model developer (name, e-mail) Prof. dr. ing. Carmen Teodosiu cteo@ch.tuiasi.ro

Modelling paradigm

Vertical Complexity Decision support system, organizing or enabling several modelling tools

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name Better Assessment Science Integrating point & Non-point Sources

Acronym **BASINS** Index 166

Web-link http://www.epa.gov/waterscience/basins/basinsv3.htm

Subject Water, catchment

Ecosystem service management	Aquaculture & commercial fishing
Description	

BASINS is a multipurpose environmental analysis system designed for regional, state, and local agencies that perform watershed and water quality-based studies. This system makes it possible to quickly assess large amounts of point and non-point source data in a format that is easy to use and understand. BASINS will help regions, states, and local agencies develop cost-effective approaches to watershed management and environmental protection. BASINS 4.0 is a valuable tool for watershed and water quality-based analyses, including developing total maximum daily load (TMDL) allocations. Unlike earlier releases, BASINS 4.0 runs on non-proprietary, open source, free geographic information system (GIS) software, making the tool universally available to anyone interested in the system. Prior versions required users to purchase costly GIS software to run the BASINS system. Once installed on a personal computer, BASINS 4.0 gives users access to large amounts of point and non-point source data, which they can use to assess or predict flow and water quality for selected streams or entire watersheds.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	time series
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	FORTRAN
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	
Time horizon	Short-term
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	Streamflow, TSS, nitrate data, precipitation, air temperature, potential evapotranspiration, solar radiation, wind speed, dew point temperature, and cloud cover
Computational outputs	forecast urbanization-induced stressors, namely flow alteration and water quality, degradation under various urban development scenarios.
Example	

Model name CORAL

Acronym **CORAL** Index

83

Web-link

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VBS-47MJ19Y-

1&_user=2728019&_coverDate=03%2F15%2F2003&_alid=1069348647&_rdoc=5&_

Subject Fauna

Ecosystem service management Aquaculture & commercial fishing

Description

A simulation model of the population dynamics of the branching coral. Was developed under the assumption that different disturbance events create changes in the relative abundances of the morphological stages that can be recognized in field surveys.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach Individual/cell-based (agents)

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s)

Graphical mapping technology Non-GIS

Geographical applicability area

Time horizon Long-term

Sectoral application area

User_friendliness

Example

Model name Ecological Dynamics Model

Acronym **EcoDynamo** Index

107

Web-link https://bdigital.ufp.pt/dspace/bitstream/10284/826/3/ecodynamo.pdf

Subject Ecosystem

Water, catchment

Ecosystem service management Aquaculture & commercial fishing

Description

EcoDynamo is an example of object oriented modelling software, built in C++ that was designed to simulate thermodynamic, hydrodynamic and biogeochemical processes of aquatic ecosystems. One important characteristic of this software is that its objects are compiled as Dynamic Link Libraries (DLLs) with an interface allowing their linkage with other modelling software codes written in FORTRAN or C. This allows different modelling teams to share software for the calculation of specific processes, independently of the programming language preferred, and enabling bidirectional code reutilisation. The EcoDynamo shell manages the graphical user interface, the communications between classes and the output devices, where the simulation results are saved. Simulated processes include:(i) hydrodynamics of aquatic systems – water elevations, current speeds and directions;(ii) thermodynamics - energy balances between water and atmosphere and water temperature;(iii) biogeochemical - nutrient and biological species dynamics;(iv) anthropogenic: e.g. biomass harvesting.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s) C++

Graphical mapping technology Raster-GIS (grids, pixels)

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example Ria Formosa Lagoon is located in the south region of

Portugal, in the Algarve province.

The Ditty project

Model name	Ecological/ecosystem modelling software suite
Acronym	**ECOPATH**
Index	139
Web-link	http://www.ecopath.org/
Subject	Ecosystem Fauna Economic
Ecosystem service management	Aquaculture & commercial fishing

Description

ecological/ecosystem modelling software suite. The Ecopath software package can be used to Address ecological questions; Evaluate ecosystem effects of fishing; Explore management policy options; Analyze impact and placement of marine protected areas; Predict movement and accumulation of contaminants and tracers (Ecotracer); Model effect of environmental changes. The Ecopath/Ecosim combination makes it possible to investigate potential changes to the ecosystem as a result of fisheries management measures.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	The sea
Time horizon	Not specified

Sectoral application area Management

User_friendliness Easy-to-use

User inputs Biomass and size structure, movement rates, Fisheries data

Computational outputs Determining appropriate unit prices for each group of fish in the fishing habitats; working cost of landing a unit of a particular group of fish using a given vessel type;

Example

Model name FAO-ICLARM Fish Stock Assessement Tools

Acronym **FISAT II** Index 113

Web-link http://www.fao.org/fi/oldsite/STATIST/FISOFT/FISAT/index.htm

Subject Fauna

Ecosystem service management Aquaculture & commercial fishing

Description

The Windows version of FiSAT (FiSAT II) is a program package consisting of methodologies for use with computers, enabling users to formulate some management options for fisheries, especially in data-sparse, tropical contexts.

Model developer (name, e-mail) Merete Tandstad merete.tandstad@fao.org

Modelling paradigm Simulative prediction

Simulative prediction approach time series

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name IFiBO

Acronym **IFiBO** Index

78

Web-link http://dce.felk.cvut.cz/ifibo/main.php

Subject

Ecosystem service management Aquaculture & commercial fishing

Description

Optimise fish farm profit according to the farm capacity and fish growth and mortality.The IFiBO consortium intends to focus on increasing the quality and effectiveness of fish production, which is very complex hydrochemical process. Such process requires the implementation of an advanced control technology, which has not been used yet in this area in Czech Republic.

Model developer (name, e-mail)

Modelling paradigm Optimization process

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area

Time horizon Not specified

Sectoral application area Management

User_friendliness

Example

Model name Longlines

Acronym **Longlines** Index 76

Web-link http://www.unuftp.is/static/fellows/document/jon05prf.pdf

Subject Water, catchment

Ecosystem service management Aquaculture & commercial fishing

Description

It combines an ecophysiology model and a box model in order to simulate growth of mussels reared in long lines andadvise for the appropriate size and mussel density of the cultivated area.Longline fisheries are the focus of this study with special consideration on how bait sizeaffects the catch rate and composition.

Model developer (name, e-mail) C. Bacher/IFREMER cbacher@ifremer.fr

Modelling paradigm Simulative prediction

Simulative prediction approach regression

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area Region-specific

Time horizon Long-term

Sectoral application area Management

User_friendliness

Example

Model name MEYDAG

Acronym **MEYDAG** Index

77

Web-link http://www.meydag.co.il/

Subject Water, catchment

Economic

Ecosystem service management Aquaculture & commercial fishing

Description

A modern and comprehensive management tool for aquaculture and to provide professional and technological solutions for a dynamic and expanding market. MEYDAG" is an essential tool which maximizes economic potential of the farm, reduces risk and increases profits, and which provides extensive reporting and analysis options (in Israel).

Model developer (name, e-mail) LGV Systems Ltd.

Modelling paradigm Optimization process

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s)

Graphical mapping technology Non-GIS

Geographical applicability area

Time horizon

Sectoral application area Management

User_friendliness

Example

Model name SALTMED

Acronym **SALTMED** Index

Web-link

http://www.nerc-wallingford.ac.uk/research/cairoworkshop/papers/publishedSALTMED.pdf

Subject	Water, catchment
	Soil and rock
	Vegetation including fungi
Ecosystem service management	Aquaculture & commercial fishing

Description

The SALTMED model includes the following key processes: evapotranspiration, plant water uptake, water and solute transport under different irrigation systems, drainage and the relationship between crop yield and water use.Accounts for the combined impact of water and osmotic stresses on biomass production and final yield and hence on the farmer's income. Has a water uptake function that accounts for vertical and horizontal root distribution while existing models only account for the vertical distribution in the best case. Is a model that runs for saline and non saline conditions. As such, it is applicable to any condition any where. Is a tool for use by experts in the management of salt-prone irrigation systems.

Model developer (name, e-mail)	R. Ragab Rag@ceh.ac.uk
Modelling paradigm	Simulative prediction
Simulative prediction approach	Richards and Convection-Dispersion Equation
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C/C++
Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	Short-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use
User inputs	Plant characteristics, soil characteristics, meteorological data, water management data

Computational outputs	Yield, potential and actual water uptake, salinity, soil matrix potential, soil moisture profiles, crop water requirements, plant growth
Example	Field observations from Egypt and Syria.

Model name Modelling Mediterranean Ecosystem Dynamics

Acronym **ModMED** Index 162

Web-link http://homepages.ed.ac.uk/modmed/index.htm

Subject Vegetation including fungi

Ecosystem service management Biodiversity conservation

Description

ModMED provides a flexible modelling environment that permits the user to model Mediterranean ecosystems in a variety of ways. Each module may model a different part of the system, and there may be a choice of modules for modelling the same part in different ways. The hierarchical approach (Laval, 1995) divides the system into the landscape, community and individual levels. The landscape-level model may contain many different community-level models of different types. Each community-level model may contain representations of many different individuals. Modularity and compatibility of modules is maintained using object-oriented programming.

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name Evaluation the medium-voltage power line network of Hungary from the bird conservation point of view

Acronym **Bird** Index 96

Web-link

http://www.unep-aewa.org/news/news_elements/2008/electrocution_hungary.htm

Subject Fauna

Ecosystem service management Biodiversity conservation

Description

1. Determine the group of threatened species by electrocution and collision withpower lines

2. Develop conservation priority maps for the species

3. Determine the relative significance of species

4. Develop final conflict maps for electrocution and collision of birds among power lines

Data input was based on field surveys, literature and conservation status. Priority of an area was based on these data and breeding and settlement data of the species.

Model developer (name, e-mail) Márton Horváth

Modelling paradigm Optimization process

Vertical Complexity Decision support system, organizing or enabling several modelling tools

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area Management

User_friendliness

User inputs Data input was based on field surveys, literature and conservation status. Priority of an area was based on these data and breeding and settlement data of the species

Computational outputs conflict map

Example

Model name Expert system for land use in Hungary

Acronym **Landuse Hungary** Index

99

Web-link http://www.tajhasznalat.hu/

Subject Ecosystem

Ecosystem service management Biodiversity conservation

Description

The algorithms help to choose the appropriate agri-environmental theme depending on the conditions and environment of an agricultural plot. The output is the evaluation of the desired land use.

Model developer (name, e-mail) ahorvath@botanika.hu

Modelling paradigm expert system

Vertical Complexity Decision support system, organizing or enabling several modelling tools

Computing platform

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area Hungary (mainly the Great Hungarian Plan)

Time horizon Long-term

Sectoral application area Management

User_friendliness Easy-to-use

User inputs requires more analyses, (c) risky, regarding ecological sustainability, (e) the given land use must be avoided.

Computational outputs The evaluation of the selected land use with the

	following values: (a) the given land use is probably favourable, (b) advantageous, but requires more analyses, (c) risky, regarding ecological sustainability, (e) the given land use must be avoided.
Example	The results of the expert system can be used e.g. in designing the participation of a parcel in agri-environmental programs, or in preparing plans for settlement development

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Model name	MY-X	
Acronym	**MY-X**	Index 97
Web-link	http://my-x.hu	
Subject	Water, catchment Fauna Vegetation including fungi Soil and rock Ecosystem Economic Atmosphere including weather Social & institutional Socio-environmental	

Ecosystem service management Biodiversity conservation

Description

http://miau.gau.hu/myx-free/index.php3?x=i0

http://miau.gau.hu/myx-free/index.php3?x=t01

http://miau.gau.hu/myx-free/index_e9.php3?x=e09

The My-X tool is attempting to provide online data mining services for each decision maker instead of being always intuitive/heuristic with the risk of instability and mistake or instead of using well known data mining tools which cause unacceptable cost (through system administration, servers, analysts, licenses, etc.). The first generation of this online tool provides (as a core method) the similarity analysis, which can be interpreted parallel as a special decision tree, an artificial neural network, benchmarking tool, price/performance optimizer or online expert system: (to say) an universal strategy for interpretation of arbitrary phenomena. The similarity analysis needs only one object-attribute-matrix (OAM) as learning pattern. There are a huge number of parameters, in order to be more efficient.

Through the provided advising tools you will know about the parameter setting.The following conversation is to determine if all necessary preconditions are met in order to use the COCO-online standard additive procedure. If not, instructions will be given to help decide which procedure to choose. All your

Model developer (name, e-mail)	Pitlik (László) pitlik@miau.gau.hu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule based
	Regression
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
	Unix
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	
Sectoral application area	Research
	Management
	Education and learning
User_friendliness	
User inputs	attribute-matrix (=learning pattern)
Computational outputs	graphs, expert system (combinatorical space)
Example	Monitoring rural development strategies, variant-analysis, forecasting

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Model name	Nature Conservation Information System (TIR)	
Acronym	**TIR**	Index
		100
Web-link	http://geo.kvvm.hu/tir_en/	

Subject Ecosystem

Ecosystem service management Biodiversity conservation

Description

The primary function of the Nature Conservation Information System is to help the work of national parks and conservation authorities by providing a country-wide database and an application developed specifically for the needs of nature conservation professionals.In addition several pieces of information and many maps are produced within the system, which can be used to provide information for the general public.

Model developer (name, e-mail) vaczi@mail.kvvm.hu

Modelling paradigm Other

Vertical Complexity Decision support system, organizing or enabling several modelling tools

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area Hungary

Time horizon

Sectoral application area Management

User_friendliness

Example Nature Conservation Information System

Model name Better Assessment Science Integrating point & Non-point Sources

Acronym **BASINS** Index 166

Web-link http://www.epa.gov/waterscience/basins/basinsv3.htm

Subject Water, catchment

Ecosystem service management Biodiversity conservation

Description

BASINS is a multipurpose environmental analysis system designed for regional, state, and local agencies that perform watershed and water quality-based studies. This system makes it possible to quickly assess large amounts of point and non-point source data in a format that is easy to use and understand. BASINS will help regions, states, and local agencies develop cost-effective approaches to watershed management and environmental protection. BASINS 4.0 is a valuable tool for watershed and water quality-based analyses, including developing total maximum daily load (TMDL) allocations. Unlike earlier releases, BASINS 4.0 runs on non-proprietary, open source, free geographic information system (GIS) software, making the tool universally available to anyone interested in the system. Prior versions required users to purchase costly GIS software to run the BASINS system. Once installed on a personal computer, BASINS 4.0 gives users access to large amounts of point and non-point source data, which they can use to assess or predict flow and water quality for selected streams or entire watersheds.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	Time series
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	FORTRAN
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	
Time horizon	Short-term
Sectoral application area	Research (descriptive)
User_friendliness	Easy-to-use
User inputs	precipitation, air temperature, potential evapotranspiration, solar radiation, wind speed, dew point temperature, and cloud cover
Computational outputs	forecast urbanization-induced stressors, namely flow alteration and water quality degradation under various urban development scenarios.
Example	

Model name	Biomapper

Acronym **Biomapper** Index

178

Web-link http://www2.unil.ch/biomapper/

Subject Fauna

Ecosystem service management Biodiversity conservation

Description

Biomapper is a kit of GIS- and statistical tools designed to build habitat suitability (HS) models and maps for any kind of animal or plant. It is centered on the Ecological Niche Factor Analysis (ENFA) that allows computing HS models without the need of absence data. Preparing the ecogeographical maps in order to use them as input for the ENFA (e.g. computing frequency of occurrence map, standardisation, masking, etc.) Exploring and comparing them by mean of descriptive statistics (distribution analysis, etc.) Computing the Ecological Niche Factor Analysis and exploring its output. Computing a Habitat Suitability map Evaluating it

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach regression

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Raster-GIS (grids, pixels)

Geographical applicability area Universal

Time horizon Not specified

Sectoral application area Research (descriptive)

User_friendliness Easy-to-use

User inputs field sampling, official databases, presence data

Computational outputs

Example

Model name BIOMOD

Acronym **BIOMOD** Index 179

Web-link http://r-forge.r-project.org/projects/biomod/

Subject Fauna

Ecosystem service management Biodiversity conservation

Description

BIOMOD is a computer platform for ensemble forecasting of species distributions, enabling the treatment of a range of methodological uncertainties in models and the examination of species-environment relationships.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach Regression

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Not specified

Sectoral application area Research (descriptive)

User_friendliness Easy-to-use

User inputs

Computational outputs

Example

Model name Desktop Garp

Acronym	**Desktop Garp**	Index 176

Web-link http://www.nhm.ku.edu/desktopgarp/

Subject Fauna

Ecosystem service management Biodiversity conservation

Description

DesktopGarp is a software package for biodiversity and ecologic research that allows the user to predict and analyze wild species distributions. This website contains a link to download the DesktopGarp software package and instructions for installing and using the package. DesktopGarp is a software package for biodiversity and ecologic research that allows the user to predict and analyze wild species distributions. The models describe environmental conditions under which the species should be able to maintain populations.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name Ecological Dynamics Model

Acronym **EcoDynamo** Index

107

Web-link https://bdigital.ufp.pt/dspace/bitstream/10284/826/3/ecodynamo.pdf

Subject Ecosystem

Water, catchment

Ecosystem service management Aquaculture & commercial fishing

Description

EcoDynamo is an example of object oriented modelling software, built in C++ that was designed to simulate thermodynamic, hydrodynamic and biogeochemical processes of aquatic ecosystems. One important characteristic of this software is that its objects are compiled as Dynamic Link Libraries (DLLs) with an interface allowing their linkage with other modelling software codes written in FORTRAN or C. This allows different modelling teams to share software for the calculation of specific processes, independently of the programming language preferred, and enabling bidirectional code reutilisation. The EcoDynamo shell manages the graphical user interface, the communications between classes and the output devices, where the simulation results are saved. Simulated processes include:

(i) hydrodynamics of aquatic systems – water elevations, current speeds and directions;

(ii) thermodynamics - energy balances between water and atmosphere and water temperature;

(iii) biogeochemical - nutrient and biological species dynamics;

(iv) anthropogenic: e.g. biomass harvesting.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s) C++

Graphical mapping technology Raster-GIS (grids, pixels)

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example — Ria Formosa Lagoon is located in the south region of Portugal, in the Algarve province.

The Ditty project

Model name EFIMOD

Acronym **EFIMOD** Index

54

Web-link www-ai.ijs.si/~ecemeaml/presentations/112-Mikhailov.pdf

Subject Ecosystem

Ecosystem service management Biodiversity conservation

Description

Comparsion different silvicultural regimes at long-term simulation, analysis of carbon budget, biodiversity and wood production of forest territory.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach Individual/cell-based (agents)

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Long-term

Sectoral application area Research (descriptive)

User_friendliness

User inputs	Air & soil temperature, precipitation, pools of soil organic Matter and nitrogen in forest floor and mineral soil, Potensial growth, specific nitrogen consumption, allocation of biomass between tree organs, tree species composition, number of trees, height, diameter with standard deviation, cutting regimes, type of cutting, rotation length
Computation outputs	Soil temperature and moisture with monthly step, pools of soil organic Matter and nitrogen in organic and mineral soil horizons, tree species composition, number of trees, height, diameter, growing stock, BA, biomass, harvested wood, removal of carbon and nitrogen from the ecosystem
Example	

Model name GeneSys

Acronym **GeneSys** Index

33

Web-link
http://www.prodinra.inra.fr/prodinra/pinra/doc.xsp?id=PROD2008f09ac2b2&uri=%2

Fnotices%2Fprodinra1%2F2009%2F02%2F&base=notices&qid=sdx_q0&p=1&n=3&

Subject Vegetation including fungi

Ecosystem service management Biodiversity conservation

Description

Using the GENESYS model quantifying the effect of cropping systems on gene escape from GM rape varieties to evaluate and design cropping systems. The spatio-temporal framework of GENESYS consists in simulating every year the life-cycle of the modelled crop relative in each field of a given region.

Simulative prediction approach	Monte Carlo simulation
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS

Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	
User inputs	The map of the simulated agricultural landscape, soil texture, moisture and structure, the seed bank, daily weather data, the crop succession
Computational outputs	
Example	
Example	Hydrologic management

Model name	Maximum Entropy	
Acronym	**Maxent**	Index
		175
Web-link	http://www.cs.princeton.edu/~schapire/maxent/	
Subject	Fauna	
Ecosystem service management	Biodiversity conservation	

Description

Based on the maximum-entropy approach for species habitat modelling. Maximum entropy modelling is a framework for integrating information from many heterogeneous information sources for classification. The data for a classification problem is described as a (potentially large) number of features. These features can be quite complex and allow the experimenter to make use of prior knowledge about what types of information are expected to be important for classification. Each feature corresponds to a constraint on the model. We then compute the maximum entropy model, the model with the maximum entropy of all the models that satisfy the constraints. This term may seem perverse, since we have spent most of the book trying to minimize the (cross) entropy of models, but the idea is that we do not want to go beyond the data. If we chose a model with less entropy, we would add `information' constraints to the model that are not justified by the empirical evidence available to us. Choosing the maximum entropy model is motivated by the desire to preserve as much uncertainty as possible.

Model developer (name, e-mail)

Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	a set of layers or environmental variables (such as elevation, precipitation, etc.), as well as a set of georeferenced occurrence locations
Computational outputs	produces a model of the range of the given species
Example	

Model name	Open Modeller	
Acronym	**Open Modeller**	Index 204
Web-link	http://openmodeller.sourceforge.net/	
Subject	Fauna	
Ecosystem service management	Biodiversity conservation	
Description		

OpenModeller aims to provide a flexible, user friendly, cross-platform environment where the entire process of conducting a fundamental niche modelling experiment can be carried out. The software includes facilities for reading species occurrence and environmental data, selection of environmental layers on which the model should be based, creating a fundamental niche model and projecting the model into an environmental scenario. A number of algorithms are provided as plugins, including GARP, Climate Space Model, Bioclimatic Envelopes, Support Vector Machines and others.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C++, Java, Python
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	a set of occurrence points (latitude/longitude) and a set of environmental layer files.
Computational outputs	
Example	Brazil

Model name	Simulation of Disturbance Activities	
Acronym	**SODA**	Index 181
Web-link	http://estebanfj.bio.purdue.edu/papers/ECOCOM157.pdf	
Subject	Social & institutional Fauna	

Ecosystem service management	Biodiversity conservation

Description

Simulation of Disturbance Activities (SODA) is a spatially explicit individual-based model designed as a flexible and transferable practical tool to explore the effects of spatial and temporal patterns of anthropogenic disturbance on wildlife.

Model developer (name, e-mail)	Victoria J. Bennett
Modelling paradigm	Simulative prediction
Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	
Operating system(s)	
Graphical mapping technology	
Geographical applicability area	Universal
Time horizon	
Sectoral application area	Management
User_friendliness	
Example	

Models of Disease hazards

Model name	MY-X	
Acronym	**MY-X**	Index 97
Web-link	http://my-x.hu	
Subject	Water, catchment Fauna Vegetation including fungi Soil and rock Ecosystem Economic Atmosphere including weather Social & institutional Socio-environmental	
Ecosystem service management	Disease hazards	
Description		

http://miau.gau.hu/myx-free/index.php3?x=i0

http://miau.gau.hu/myx-free/index.php3?x=t01

http://miau.gau.hu/myx-free/index_e9.php3?x=e09

The My-X tool is attempting to provide online data mining services for each decision maker instead of being always intuitive/heuristic with the risk of instability and mistake or instead of using well known data mining tools which cause unacceptable cost (through system administration, servers, analysts, licenses, etc.). The first generation of this online tool provides (as a core method) the similarity analysis, which can be interpreted parallel as a special decision tree, an artificial neural network, benchmarking tool, price/performance optimizer or online expert system: (to say) an universal strategy for interpretation of arbitrary phenomena. The similarity analysis needs only one object-attribute-matrix (OAM) as learning pattern. There are a huge number of parameters, in order to be more efficient. Through the provided advising tools you will know about the parameter setting.The following conversation is to determine if all necessary preconditions are met in order to use the COCO-online standard additive procedure. If not, instructions will be given to help decide which procedure to choose. All your

Model developer (name, e-mail)	Pitlik (László) pitlik@miau.gau.hu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule based
	Regression
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
	Unix
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	
Sectoral application area	Research
	Management
	Education and learning
User_friendliness	
User inputs	attribute-matrix (=learning pattern)
Computational outputs	graphs, expert system (combinatorical space)

Example	Monitoring rural development strategies, variant-analysis, forecasting

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Model name	NCSU/APHIS Plant Pest Forecast System	
Acronym	**NAPPFAST**	Index 34
Web-link	http://www.nappfast.org/	
Subject	Vegetation including fungi	
	Atmosphere including weather	

Ecosystem service management — Disease hazards

Description

Internet-based Pest Prediction System for plant pest modelling using georeferenced climatological weather data.

Model developer (name, e-mail)	Dan Borchert, Peg Margosian
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name Prediction

Acronym **Prediction** Index

39

Web-link
http://users.rsise.anu.edu.au/~kzhang/Ke%20Zhang%20homepage/discovering%20
prediction%20models%20for%20environmental%20distribution%20maps.pdf

Subject Socio-environmental

Atmosphere including weather

Ecosystem service management Disease hazards

Description

Formally, we can fit our general concept of prediction into the frame of the modelling scheme, if we even further expand the range of possible actions a, namely, allow for a being an arbitrary process which may include both actions of the subject of the model, and any other actions and processes. Let the brain of the subject be always found in one of only two states, let them have the names True and False. The representation function M_a(w) will result in True if w is the end state of the process a which succeeded, and False otherwise. The modelling function M(r) will be universal and very simple: it immediately produces the object True. Now the model we built makes exactly one prediction : that the process a ends in success.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach Individual/cell-based (agents)

Vertical Complexity Published statistical relationship (regression, rate or other formula)

Computing platform Internet-linked Servers

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Not specified

Sectoral application area

User_friendliness Easy-to-use

User inputs

Computational outputs

Example wildfire prediction model

Model name AQUARIUS

Acronym **AQUARIUS** Index

113

Web-link http://www.ici.ro/produse/aquarius.html

Subject Atmosphere including weather

Water, catchment

Ecosystem service management Disease hazards

Description

AQUARIUS is a software instrument for monitoring environmental parameters, air and water pollution simulation and control. It is a very good choice when major decisions related to a sustainable development need to be made. AQUARIUS is based on a library which contains simulation and control models for environment protection (air, water). The models have a hybrid structure since they are composed of several interconnected models with various natures. AQUARIUS may be used by any industrial firm or environmental protection organization. It is an instrument for the monitoring of environmental parameters and may be used for decision making in order to mitigate the pollution. AQUARIUS is designed for managers who are involved in decision making processes that may lead to environment pollution: •design and manage their own data collections and parameters regarding environment pollution;

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name Rain Forest Growth Simulation Model

Acronym **FORMIX** Index

50

Web-link http://eco.wiz.uni-kassel.de/model_db/mdb/formix.html

Subject Ecosystem

Ecosystem service management Disease hazards

Description

A dynamic simulation model for the growth of tropical rain forest. For each species group the model calculates biomass and tree number in five distinct canopy layers. This model cannot account for the effects of climate change; photosynthesis is empirically based: and model does not simulate soil water balance, soil carbon fluxes and heterotrophic respiration. The model has proved usefull for studies on allometry and forest management.

Model developer (name, e-mail) Andreas Huth huth@usf.uni-kassel.de

Modelling paradigm Simulative prediction

Simulative prediction approach Individual/cell-based (agents)

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) DOS

Modelling language(s) Turbo Pascal, C

Graphical mapping technology Non-GIS

Geographical applicability area Region-specific

Time horizon Long-term

Sectoral application area

User_friendliness

Example FORMIX was applied in combination with a geographic information system. The study was carried out for the 55 084 ha of the Deramakot Forest Reserve in Canada.

Model name Human Health Risk Assessment

Acronym **RISC** Index 22

Web-link http://www.groundwatersoftware.com/risc.htm

Subject Social & institutional

Ecosystem service management Disease hazards

Description

Is a software package for performing fate and transport modelling and human health risk assessments for contaminated sites. Estimate receptor point concentrations in groundwater and indoor and outdoor air. Can be used to estimate the potential for adverse human health impacts (both carcinogenic and non-carcinogenic) from up to nine exposure pathways.RISC is a consumer values survey www.risc-int.com .

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach Markov process

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Not specified

Sectoral application area Management

User_friendliness Expert assistance required

Example

Model name SIERRA

Acronym **SIERRA** Index 63

Web-link http://www.evenor-tech.com/microleis/microlei/microlei.aspx

Subject Fauna

Socio-environmental

Ecosystem service management Disease hazards

Description

Sierra comprises two modules "Description of forest species", detailing the edaphoclimatic requirements of 22 typical Mediterranean forest species; and an evaluation module, for selecting the best species for the land-unit evaluated.

Model developer (name, e-mail) Prof. D. de la Rosa

Modelling paradigm Simulative prediction

Simulative prediction approach Rule-based

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s)

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Not specified

Sectoral application area Research (descriptive)

User_friendliness

User inputs Site-, soil-, crop-, climate-related variables

Computational outputs	For all the species analyzed, positive results are listed on-screen as species appropriate for that site

Example

Models of Environment

Model name SOZAT

Acronym **SOZAT** Index

111

Web-link http://www1.atmoterm.pl/en/products/sozat/

Subject Atmosphere including weather

Ecosystem service management Environment

Description

SOZAT is a unique tool for managing global and local and enterprise greenhouse emission data. The system is specialized for calculating greenhouse gases emission from raw material data through engineering processes. It enables to enter and process all emission data in a unified methodology in the whole company or corporation. SOZAT is an integrated environmental suite of modules which together contain the most critical types of industrial environmental emission and impacts such as:

- ECO2
- ISO 14000-SOZAT
- Air emission module
- Waste module
- Water module
- Wastewater module

Model developer (name, e-mail) ATMOTERM S.A.

Modelling paradigm Simulative prediction

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	
Sectoral application area	Management
	Education
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name	Lenne3D	
Acronym	**Lenne3D**	Index
		67
Web-link	http://www.lenne3d.com/content/view/48/110/lang,en/	
Subject	Ecosystem	

Ecosystem service management Environment

Description

Lenné3D offers customized visualisation services for the visualisation of rural and urban landscape, and gardens through real-time applications, animation and static images.

Model developer (name, e-mail)	Philip Paar
Modelling paradigm	
Vertical Complexity	
Computing platform	
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	
Geographical applicability area	

Time horizon

Sectoral application area

User_friendliness

Example

Model name The Biodiversity Assessment Project

Acronym **BAP toolbox** Index

44

Web-link http://giant.lakeheadu.ca/carisweb/hsm/bap reports/bap reports main.htm

Subject Ecosystem

Ecosystem service management Environment

Description

Is a suite of indicator models used to assess diverse forest management strategies at three levels of biodiversity: landscape patterns, ecosystem diversity, and habitat supply for specific vertebrate species. Translates a time series of landscape conditions output from landscape models into habitat types that serve as spatial units for ecosystem and the landscape biodiversity (i.e., coarse-filter) assessment.

Model developer (name, e-mail) Doyon and Duinker

Modelling paradigm Multi-criteria analysis

Vertical Complexity Decision support system, organizing or enabling several modelling tools

Computing platform

Operating system(s)

Graphical mapping technology Raster-GIS (grids, pixels)

Geographical applicability area Universal

Time horizon Long-term

Sectoral application area Management

User_friendliness

User inputs	forest age
Computational outputs	
Example	Labrador District 19A toolkit & meta-model

Model name	MABES	
Acronym	**MABES**	Index 29
Web-link	http://www.ncbi.nlm.nih.gov/pubmed/17355569	
Subject	Ecosystem	
Ecosystem service management	Environment	

Description

Many ecosystem services are delivered by organisms that depend on habitats that are segregated spatially or temporally from the location where services are provided. Management of mobile organisms contributing to ecosystem services requires consideration not only of the local scale where services are delivered, but also the distribution of resources at the landscape scale, and the foraging ranges and dispersal movements of the mobile agents. We develop a conceptual model for exploring how one such mobile-agent-based ecosystem service (MABES), pollination, is affected by land-use change, and then generalize the model to other MABES. The model includes interactions and feedbacks among policies affecting land use, market forces and the biology of the organisms involved. Animal-mediated pollination contributes to the production of goods of value to humans such as crops; it also bolsters reproduction of wild plants on which other services or service-providing organisms depend. About one-third of crop production depends on animal pollinators, while 60-90% of plant species require an animal pollinator. The sensitivity of mobile organisms to ecological factors that operate across spatial scales makes the services provided by a given community of mobile agents highly contextual. Services vary, depending on the spatial and temporal distribution of resources surrounding the site, and on biotic interactions occurring locally, such as competition among pollinators for

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon

Sectoral application area Management

User_friendliness

Example

Model name System of Integrated Environmental and economic Accounting

Acronym **SEEA** Index 132

Web-link http://unstats.un.org/unsd/envaccounting/seea.asp

Subject Economic

Ecosystem service management Environment

Description

SEEA 2003, is a satellite system of the System of National Accounts. It brings together economic and environmental information in a common framework to measure the contribution of the environment to the economy and the impact of the economy on the environment. It provides policy-makers with indicators and descriptive statistics to monitor these interactions as well as a database for strategic planning and policy analysis to identify more sustainable paths of development.

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity

Computing platform Internet-linked Servers

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Models of farming

Model name SALTMED

Acronym **SALTMED** Index

14

Web-link

http://www.nerc-wallingford.ac.uk/research/cairoworkshop/papers/publishedSALTMED.pdf

Subject Water, catchment

Soil and rock

Ecosystem service management Farming

Description

The SALTMED model includes the following key processes: evapotranspiration, plant water uptake, water and solute transport under different irrigation systems, drainage and the relationship between crop yield and water use. Accounts for the combined impact of water and osmotic stresses on biomass production and final yield and hence on the farmer's income. Has a water uptake function that accounts for vertical and horizontal root distribution while existing models only account for the vertical distribution in the best case. Is a model that runs for saline and non saline conditions. As such, it is applicable to any condition any where. Is a tool for use by experts in the management of salt-prone irrigation systems.

Model developer (name, e-mail) R. Ragab Rag@ceh.ac.uk

Modelling paradigm Simulative prediction

Simulative prediction approach Richards and Convection-Dispersion Equation

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s) C/C++

Graphical mapping technology	Non-GIS
Geographical applicability area	
Time horizon	Short-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	Plant characteristics, soil characteristics, meteorological data, water management data
Computational outputs	yield, potential and actual water uptake, salinity, soil matrix potential, soil moisture profiles, crop water requirements, plant growth
Example	Field observations from Egypt and Syria.

Models of Forecast

Model name	Real Options	
Acronym	**Real Options**	Index
		43
Web-link	http://en.wikipedia.org/wiki/Real_options_analysis	
Subject	Economic	

Ecosystem service management	Forecast

Description

A numerical analysis approach used in economics to inform decisions with irreversible consequences that affect a real asset. Monte Carlo simulation must be used together with some optimization method

Model developer (name, e-mail)	Dixit and Pindyck
Modelling paradigm	Simulative prediction
Simulative prediction approach	Monte Carlo
Vertical Complexity	Published statistical relationship (regression, rate or other formula)

Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Visual Basic
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Models of Heritage conservation

Model name Nature Conservation Information System (TIR)

Acronym **TIR** Index 100

Web-link http://geo.kvvm.hu/tir_en/

Subject Ecosystem

Ecosystem service management Heritage conservation

Description

The primary function of the Nature Conservation Information System is to help the work of national parks and conservation authorities by providing a country-wide database and an application developed specifically for the needs of nature conservation professionals.In addition several pieces of information and many maps are produced within the system, which can be used to provide information for the general public.

Model developer (name, e-mail)	vaczi@mail.kvvm.hu
Modelling paradigm	Other
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	

Operating system(s)

Graphical mapping technology

Geographical applicability area Hungary

Time horizon

Sectoral application area Management

User_friendliness

Example Nature Conservation Information System

Model name Educational and decision-making new model for sustainable development activation based on innovative web services and quality resoning.

Acronym **NATURNET-REDIME** Index 116

Web-link **Tõrge! Lubamatu hüperlingiviide.**

Subject Ecosystem

Economic

Socio-environmental

Ecosystem service management Heritage conservation

Description

The general objective of NaturNet-Redime is to support sustainable development by improving knowledge about all aspects of sustainability and provide education mainly about social, economic, and environmental tools for the implementation of the EU Strategy on Sustainable Development at both EU and international levels . Naturnet-Redime will establish connections with other running projects like IQ TOOLS, SUSTAINABILITY A-TEST, MULTAGRI, METHODEX, TIGRESS, INSEA, KASSA, etc to support learnng about their tools.There are two main approaches of the NaturNet-Redime project, which originate from the two proposals that have merged to create the combined project. The first is the NaturNet - Redime portal, which focuses on innovative presentation of different tools and data sources for learning about sustainability. The second is learning through modelling, where learners develop deep understanding of causes and effects by developing their own models of particular systems - using Qualitative Reasoning (QR). This approach will also be accessible to the public via the NaturNet-Redime portal.

The focus will be on how to manage sustainable tourism in regions and mainly in sensitive areas as protected areas, national parks and coastal zones.

Model developer (name, e-mail)	Daniel Deybe Daniel.DEYBE@cec.eu.int
Modelling paradigm	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	
Time horizon	
Sectoral application area	Research (descriptive) Education
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name	MY-X	
Acronym	**MY-X**	Index 97
Web-link	http://my-x.hu	
Subject	Water, catchment Fauna Vegetation including fungi Soil and rock Ecosystem Economic Atmosphere including weather Social & institutional Socio-environmental	

Ecosystem service management	Heritage conservation

Description

http://miau.gau.hu/myx-free/index.php3?x=i0

http://miau.gau.hu/myx-free/index.php3?x=t01

http://miau.gau.hu/myx-free/index_e9.php3?x=e09

The My-X tool is attempting to provide online data mining services for each decision maker instead of being always intuitive/heuristic with the risk of instability and mistake or instead of using well known data mining tools which cause unacceptable cost (through system administration, servers, analysts, licenses, etc.). The first generation of this online tool provides (as a core method) the similarity analysis, which can be interpreted parallel as a special decision tree, an artificial neural network, benchmarking tool, price/performance optimizer or online expert system: (to say) an universal strategy for interpretation of arbitrary phenomena. The similarity analysis needs only one object-attribute-matrix (OAM) as learning pattern. There are a huge number of parameters, in order to be more efficient. Through the provided advising tools you will know about the parameter setting.The following conversation is to determine if all necessary preconditions are met in order to use the COCO-online standard additive procedure. If not, instructions will be given to help decide which procedure to choose. All your

Model developer (name, e-mail)	Pitlik (László) pitlik@miau.gau.hu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule based
	Regression
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
	Unix
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	
Sectoral application area	Research
	Management
	Education and learning
User_friendliness	

User inputs	attribute-matrix (=learning pattern)
Computational outputs	graphs, expert system (combinatorical space)
Example	Monitoring rural development strategies, variant-analysis, forecasting

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Models of Land suitability

Model name	SIERRA	
Acronym	**SIERRA**	Index
		63
Web-link	http://www.evenor-tech.com/microleis/microlei/microlei.aspx	
Subject	Fauna	
	Socio-environmental	

Ecosystem service management Land suitability

Description

Sierra comprises two modules "Description of forest species", detailing the edaphoclimatic requirements of 22 typical Mediterranean forest species; and an evaluation module, for selecting the best species for the land-unit evaluated.

Model developer (name, e-mail)	Prof. D. de la Rosa
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	
User inputs	Site-, soil-, crop-, climate-related variables

Computational outputs	For all the species analyzed, positive results are listed on-screen as species appropriate for that site
Example	

Models of Land use planning

Model name	Automated System for Evaluating and Management the Natural Soil Fertility
Acronym	**MARISMA** Index 19
Web-link	http://www.evenor-tech.com/microleis/microlei/microlei.aspx
Subject	Wetland Vegetation including fungi
Ecosystem service management	Land use planning
Description	

Gives special emphasis to the soil chemical quality, but also considers several soil physical parameters related with the textural class.

Model developer (name, e-mail)	D. de la Rosa
Modelling paradigm	Simulative prediction
Simulative prediction approach	Qualitative
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	Easy-to-use
User inputs	

Computational outputs

Example

Model name The Spatially Explicit Landscape Event Simulator

Acronym **SELES** Index

35

Web-link http://www.ncgia.ucsb.edu/conf/SANTA_FE_CD-ROM/sf_papers/fall_andrew/fall.html

Subject

Ecosystem service management Landscape

Description

Is a raster-based tool for constructing, running and visualizing spatial landscape models that integrate natural and anthropogenic processes (e.g., fire, insects, logging, and succession). It can also perform spatial analysis (e.g., habitat connectivity), and track indicators (e.g., age class, habitat supply, growing stock) over long time-frames and large spatial areas. SELES is a research tool as well as a decision-support tool for problems related to conservation and resource management. These models are useful for exploring the effect of natural disturbance and succession on landscape structure.

Model developer (name, e-mail) fall@cs.sfu.ca

Modelling paradigm Simulative prediction

Simulative prediction approach

Vertical Complexity Decision support system, organizing or enabling several modelling tools

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Raster-GIS (grids, pixels)

Geographical applicability area Universal

Time horizon Long-term

Sectoral application area

User_friendliness Easy-to-use

User inputs

Computational outputs

Example natural and anthropogenic processes

Model name The plant architectural model

Acronym **AMAP/Imagis** Index 69

Web-link http://umramap.cirad.fr/amap2/logiciels_amap/index.php?page=amapsim

Subject

Ecosystem service management Landscape

Description

IMAGIS is an interface between the 2 D world of plans and the 3 D world of perspectives. It implements a set of procedures specifically designed to transform landscape forms described in a GIS quite synthetically by 2 D entities, into much more elaborate objects in a 3 D space. It is intended for creating broad landscape models, from which photorealistic images can be computed with Atelier de Modélisation de l'Architecture des Plantes (AMAP) software. AMAP is a modelling workshop allowing users to generate and visualize a large number of plant models at various growth stages. AMAP was created from the outset for the needs of agronomists who seek to simulate very accurately the architecture and growth behavior of plants, in a natural or a designed environment. It is now quite established in the realm of landscape architecture. IMAGIS is aiming at a different community of users: the planning and GIS organizations who need to visualize regional development plans for impact assessment, communication and decision-making purposes. Although, it may be applied in a wide variety of contexts, its built-in features makes it particularly suitable for suburban planning.

Model developer (name, e-mail) amapsim@cirad.fr

Modelling paradigm Simulative prediction

Simulative prediction approach

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s) Unix, Linux or other Unix-like

Graphical mapping technology Vector-GIS (polygons, lines, points)

Geographical applicability area Universal

Time horizon Long-term

Sectoral application area

User_friendliness

Example landscape visualisation

Model name LANDIS-II

Acronym **LANDIS-II** Index

40

Web-link http://www.landis-ii.org/

Subject

Ecosystem service management Landscape

Description

Using to investigate the strength of interactions between forest succession, harvesting, and fire disturbance processes. Model integrate ecosystem prosecc, aboveground living biomass, and dead biomass for landscape change;quantify the influence of multiple disturbances on aboveground biomass and spspecies composition and evaluate model results and conduct a sensitivity analysis of the model parameters.

Model developer (name, e-mail) Scheller and Mladenoff

Modelling paradigm Simulative prediction

Simulative prediction approach

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Distributed Processing (e.g. GRID)

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Raster-GIS (grids, pixels)

Geographical applicability area

Time horizon Long-term

Sectoral application area

User_friendliness

Example processes forest succession, harvesting, and fire disturbance

Model name A Spatially Explicit Landscape Event Simulator

Acronym **SELES** Index 97

Web-link http://seles.info/index.php?title=Main_Page

Subject Ecosystem

Ecosystem service management Landscape

Description

These models are useful for exploring the effect of natural disturbance and succession on landscape structure. Intermediate results may be analyzed to determine how structure changes over time and Monte-Carlo simulations may be used to determine how much variation in structure might be expected from the same set of landscape processes. Is a raster-based tool for constructing, running and visualizing spatial landscape models that integrate natural and anthropogenic processes (e.g., fire, insects, logging, and succession). It can also perform spatial analysis (e.g., habitat connectivity), nd track indicators (e.g., age class, habitat supply, growing stock) over long time-frames and large spatial areas. SELES is a research tool as well as a decision-support tool for problems related to conservation and resource management. These models are useful for exploring the effect of natural disturbance and succession on landscape structure.

Model developer (name, e-mail) Andrew Fall, fall@cs.sfu.ca

Modelling paradigm Simulative prediction

Simulative prediction approach Monte-Carlo

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	Research (descriptive) Management
User_friendliness	Easy-to-use
User inputs	Elevation, slope, moisture, soil, habitat feature, time of last transistion
Computational outputs	
Example	1. Labrador District 19A toolkit & meta-model 2. This model has been adapted and applied in five broad landscapes in northern and central B.C. and west central Albera, Canada. 4. Fire Suppression in a Western Hemlock/Douglas Fir Landscape 5. Garden mode

Models of learning

Model name System of Multiple Attribute Decision Making

Acronym **MADM** Index 149

Web-link **Tõrge! Lubamatu hüperlingiviide.**

Subject

Ecosystem service management learning

Description

Software for selftraining in decision making

Model developer (name, e-mail) Cornel Resteanu resteanu@ici.ro

Modelling paradigm

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Models of Physical hazards

Model name Software application for the environmental parameters monitoring

Acronym **AQUARIUS** Index 113

Web-link http://www.ici.ro/produse/aquarius.html

Subject Atmosphere including weather

Water, catchment

Ecosystem service management Physical hazards

Description

Software application

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name Fire Behaivor

Acronym **Fire Behaivor** Index

38

Web-link

http://www.epa.gov/ecopage/upland/oak/oak93/stanton1.htm - MODEL FIRE

Subject Ecosystem

Socio-environmental

Ecosystem service management Physical hazards

Description

Predict rate of spread (ROS) and flame length (FL), estimate the area and perimeter of a fire. It uses assumptions of an average worst case scenario

Model developer (name, e-mail) Roethermal, Andrews, Byrom, Albini

Modelling paradigm Simulative prediction

Simulative prediction approach regression

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Raster-GIS (grids, pixels)

Geographical applicability area Universal

Time horizon Short-term

Sectoral application area Management

Education

User_friendliness Easy-to-use

User inputs

Computational outputs

User inputs spreed distance, midflame windspreed

Computational outputs Maximum spotting distance, probability of ignition

Example

Model name System of evaluation of the risk in the areas contaminated with heavymetals

Acronym **FITORISC** Index

117

Web-link http://www.modelare-ecologica.ro/proiecte/fitorisc/

Subject Economic

Ecosystem service management Physical hazards

Description

Luarea deciziilor cu privire la managementul zonelor contaminate cu metale presupune doua etape: 1) evaluarea riscului asociat transferului metalelor din sol si, in cazul in care acest risc este substantial, 2) stabilirea solutiilor optime de remediere a zonei contaminate. Bioremedierea in general si fitoremedierea in particular se afla printre cele mai importante directii de dezvoltare a tehnicilor de remediere pe plan international si sunt insotite de simularea efectelor aplicarii tehnicilor prin modelare matematica. In acest context, proiectul FITORISC se adreseaza urmatoarele directii prioritare: 3.3.3 Eco-tehnologii de reabilitare si reconstructie ecologica; tehnologii de remediere a solurilor contaminate.

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name System of economic evaluation of the stabile pollutants retention in river systems

Acronym **PECOTOX** Index

118

Web-link http://www.modelare-ecologica.ro/proiecte/pecotox/

Subject Economic

Ecosystem service management Physical hazards

Description

Dincolo de optiunea utilizarii metodelor care isi propun remedierea zonelor contaminate cu poluanti toxici stabili, un rol cheie in controlul acestui tip de poluare il are managementul ecosistemelor antropizate care functioneza ca sursa de poluare in bazinele hidrografice, precum si cel al ecosistemelor naturale si seminaturale care functioneaza ca tampon intre sistemele sursa si cele receptoare. In acest context, proiectul se adreseaza urmatoarele prioritati: 3.3.1 Diversitatea biologica, geologica si ecologica la nivel local, regional si national (caracterizare, identificarea factorilor de comanda si presiune, identificarea functiilor componentelor diversitatii biologice, geologice si ecologice, evaluarea sociala si economica)

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name Enhanced Stream Water Quality Model with Uncertainty Analysis

Acronym **QUAL2EU** Index

167

Web-link http://www.epa.gov/docs/QUAL2E_WINDOWS/index.html

Subject Water, catchment

Ecosystem service management Physical hazards

Description

The Enhanced Stream Water Quality Model (QUAL2E) is a steady state model for conventional pollutants in branching streams and well mixed lakes. It can be operated either as a steady-state or dynamic model and is intended for use as a water quality planning tool. The model can be used to study impact of waste loads on in stream water quality and identify magnitude and quality characteristics of non-point waste loads. The Enhanced Stream Water Quality Model with Uncertainty Analysis (QUAL2EU) is an enhancement to the QUAL2E model that allows the user to perform uncertainty analysis. Three uncertainty options are available. AQUAL2 is an interactive data preprocessor program for the QUAL2E and QUAL2EU models. AQUAL2 can be used to build input data files for either model. Q2PLOT is an interactive data post processor program for both.

Model developer (name, e-mail)

Modelling paradigm

Vertical Complexity

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Model name Spatial Modelling Environment

Acronym **SME3** Index 165

Web-link http://www.uvm.edu/giee/SME3/

Subject Ecosystem

Ecosystem service management Physical hazards

Description

The SME allows a scientist to construct sophisticated models of ecosystems in a point-and-click graphical environment. An ecosystem cell model is developed using a graphical modelling tool STELLA models can simulate photosynthesis, soil chemistry, or any other process operating in a particular kind of landscape. But in isolation, they are like symphony musicians playing in individual sound-proof rooms. The musicians may all be virtuosos, but they can't play in harmony. To behave like an ecosystem, the STELLA models have to be able to "hear" each other. Villa is also gearing up to take the SME concept to the next level with a tool he has dubbed the Integrating Modelling Architecture (IMA). The IMA would allow spatial and non-spatial models to be linked together seamlessly into a high-level model. This will enable researchers to bridge very different kinds of models. For example, a model of the population dynamics of deer (modelling based on individual organisms) could be run within a model of plant growth in a forest (modelling based on a process). The different models could be defined and linked together by dragging and dropping icons on a computer desktop.

Model developer (name, e-mail)	Thomas Maxwell tmaxwell@zoo.uvm.edu
Modelling paradigm	Optimization process
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Modular Modelling Language (MML), C++, Java
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Not specified

Sectoral application area

User_friendliness Easy-to-use

User inputs

Computational outputs

Example

Model name Soil Water In Forested ecosystems model

Acronym **SWIF** Index

169

Web-link W.Bouten@frw.uva.nl

Subject

Ecosystem service management Physical hazards

Description

SWIF (Soil Water In Forested) ecosystems model is part of a larger model, called ForHyd (Forest-Hydrological) model (Bouten and Witter, 1992). At present, ForHyd includes three other modules:

•Makkink for calculating potential evapotranspiration;

•SBound to calculate through fall amounts, potential transpiration and potential soil evaporation in a simple, empirical

way, and,

•a multi-layer module to simulate canopy water storage and through fall.

•parameters of the drainage function,

•crop parameters,

•water retention characteristics and

•pressure head profile.

The temporal scale of the model is days to years. It is widely used in the Forest Service.

Model developer (name, e-mail)

Modelling paradigm Optimization process

Vertical Complexity	
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	Research (descriptive)
User_friendliness	Easy-to-use
User inputs	rainfall, potential evapotranspiration, groundwater level
Computational outputs	the root densities in each layer
Example	part of Forest-Hydrological model

Model name	Integrated system, decisional support based on multisensorial information fusion for behavior surveillance and prediction of dams and hydropower plant	
Acronym	**FUZIBAR**	Index 166
Web-link	http://www.automation.ro/fuzibar/	
Subject	Water, catchment	
Ecosystem service management	Physical hazards	

Description

FUZIBAR is to provide a reliable instrument for the assessment and control of the risk, in order to ensure the conditions for the sustainable development of the hydrotechnical sites surrounding areas. Will assist the surveillance and the behavior prediction of hydrodams and hydrotechnical sites

Model developer (name, e-mail)	
Modelling paradigm	Multi-criteria analysis

Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Matlab, C++
Graphical mapping technology	Non-GIS
Geographical applicability area	Management
Time horizon	Not specified
Sectoral application area	
User_friendliness	
User inputs	Numerical information from the electromechanical sensors images from the dry surface of the dam's, the surveillance and control devices embedded within the dam body ,image in infrared spectrum
Computational outputs	Decision process in safe surveillance of the dams.
Example	

Model name New and innovative model used as scientific tool in decision making on protection and ecological reconstruction of wetlands

Acronym **MORFDD** Index 124

Web-link
http://www.indd.tim.ro/morfdd/index.php?option=com_content&task=view&id=14&Itemid=30&lang=english

Subject Water, catchment

Ecosystem

Ecosystem service management Physical hazards

Description

New and innovative model used as scientific tool in decision making on protection and ecological reconstruction of wetlands and preservation of protected areas based on mathematical modelling of morphohydrography and water quality. For this type of system, decisions relate, mainly, to rehabilitation /improvement of ecological factors through a sustainable management of wetlands hydrographic network.

Model developer (name, e-mail)	Eugenia CIOACA
Modelling paradigm	Simulative prediction
Simulative prediction approach	regression
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Region-specific
Time horizon	Not specified
Sectoral application area	Research (descriptive) Management
User_friendliness	Expert assistance required
User inputs	geospatial data
Computational outputs	numerical simulations of real (possible) scenarios for morphology changes and water quality within DDR aquatic ecosystems (fluvial, lake, and marine coastal zone)
Example	Danube River-Danube Delta-Black Sea geo-ecosystem

Model name	MY-X	
Acronym	**MY-X**	Index 97
Web-link	http://my-x.hu	
Subject	Water, catchment Fauna Vegetation including fungi	

Soil and rock
Ecosystem
Economic
Atmosphere including weather
Social & institutional
Socio-environmental

Ecosystem service management	Physical hazards

Description

http://miau.gau.hu/myx-free/index.php3?x=i0

http://miau.gau.hu/myx-free/index.php3?x=t01

http://miau.gau.hu/myx-free/index_e9.php3?x=e09

The My-X tool is attempting to provide online data mining services for each decision maker instead of being always intuitive/heuristic with the risk of instability and mistake or instead of using well known data mining tools which cause unacceptable cost (through system administration, servers, analysts, licenses, etc.). The first generation of this online tool provides (as a core method) the similarity analysis, which can be interpreted parallel as a special decision tree, an artificial neural network, benchmarking tool, price/performance optimizer or online expert system: (to say) an universal strategy for interpretation of arbitrary phenomena. The similarity analysis needs only one object-attribute-matrix (OAM) as learning pattern. There are a huge number of parameters, in order to be more efficient. Through the provided advising tools you will know about the parameter setting.The following conversation is to determine if all necessary preconditions are met in order to use the COCO-online standard additive procedure. If not, instructions will be given to help decide which procedure to choose. All your

Model developer (name, e-mail)	Pitlik (László) pitlik@miau.gau.hu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule based
	Regression
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
	Unix
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	

Sectoral application area	Research
	Management
	Education and learning
User_friendliness	
User inputs	attribute-matrix (=learning pattern)
Computational outputs	graphs, expert system (combinatorical space)
Example	Monitoring rural development strategies, variant-analysis, forecasting

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Model name Model software solution for risk management information system

Acronym **TERRARISC** Index 141

Web-link **Tõrge! Lubamatu hüperlingiviide.**

Subject Soil and rock

Ecosystem service management Physical hazards

Description

Decision support for risk management of landslides occurrence. The system will integrate technologies regarding:

- On-line environmental parameters capture
- wireless communication
- Relational Data Based System
- Business Intelligence
- Data Mining and Pattern recognition, simulation techniques based on theory of probability in order to obtain landslide models
- GIS systems
- Mobile access devices

Model developer (name, e-mail)	OLARU V., STOIAN I.
Modelling paradigm	Simulative prediction

Simulative prediction approach	Rule-based
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Region-specific
Time horizon	Long-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	prognosis of the risk
to landslides	Example

Model name	Sistem Suport de Decizie in Gestiunea Apelor Urbane	
Acronym	**URBAWATER**	Index 119
Web-link	http://hidrotehnica.utcb.ro/programe/urbwater	
Subject	Water, catchment	
Ecosystem service management	Physical hazards	
Description		

Obiective generale:

1) Determinarea zonelor vulnerabile la inundaţii produse de cursurile de apă din amonte, apele de şiroire de pe versanţii zonelor înconjurătoare şi pe ariile urbane, precum şi măsuri de reducere a efectului inundaţiilor

2) Evaluarea consecinţelor poluării cronice asupra emisarului, identificarea surselor de

poluare accidentală, a condiţiilor de producere, a modului de transport al poluanţilor, precum şi măsuri de gestionare a crizei în caz de poluare.

Model developer (name, e-mail)	Prof. Radu Drobot
Modelling paradigm	
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	
Geographical applicability area	
Time horizon	
Sectoral application area	
User_friendliness	
Example	

Model name	Soil Water and CROP production model	
Acronym	**SWACROP**	Index 7
Web-link	http://www.bib.wau.nl/dlo/sc-dlo.html	
Subject	Water, catchment Soil and rock Ecosystem	
Ecosystem service management	Physical hazards	
Description		

Keywords: unsaturated zone, soil evaporation, soil water, crop production, soil water flow, potato, wheat, maize, grass, irrigation, drainage

Is a transient one-dimensional finite difference model for simulation of the unsaturated zone. It incorporates the process of water uptake by roots. The soil profile is divided into several layers (containing one or more compartments of variable thickness) having different physical properties.SWACROP (Soil WAter and CROP production model) is a transient one-dimensional finite difference model for simulation of the unsaturated zone. It incorporates the process of water uptake by roots. The soil profile is divided into several layers (containing one or more compartments of variable thickness) having different physical properties. The partial differential equation for flow in the unsaturated system is solved using an implicit finite difference scheme. An explicit linearization of the hydraulic conductivity (K) and soil water capacity (C) is used. Knowing the initial conditions (i.e. water content or pressure head distribution profile) and top and bottom boundary conditions, the system of equations for all the compartments is solved for each (variable) time step by applying the so-called Thomas tridiagonal algorithm. The integration procedure within each time step allows calculation of all water balance terms for

Model developer (name, e-mail)	wesseling@sc.agro.nl
Modelling paradigm	Simulative prediction
Simulative prediction approach	finite differences
Vertical Complexity	Published statistical relationship (regression, rate or other formula)
Computing platform	Single computer/PDA
Operating system(s)	DOS
Modelling language(s)	FORTRAN-77
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	the hydraulic conductivity (K) and soil water capacity (C), data on rainfall, potential soil evaporation, and potential transpiration, pressure head, zero flux, or free drainage
Computational outputs	the ground-water level, the rate of potential and actual vegetation growth
Example	

http://www.mines.edu/research/igwmc/

Model name Physiological Processes Predicting Growth

Acronym **3-PG** Index 47

Web-link http://www.fsl.orst.edu/bevr/model.html

Subject Vegetation including fungi

Ecosystem service management Physical hazards

Description

Calculates the radiant energy absorbed by forest canopies and converts it into biomass production. The efficiency of radiation conversion is modified by the effects of nutrition, soil drought (the model includes continuous calculation of water balance), atmospheric vapour pressure deficits and stand age. The carbon produced by the canopy is allocated to leaves, stems and roots, using dynamic equations that update the state of the system on a monthly time step.

Model developer (name, e-mail)	Joe Landsberg and Dick Waring (1997)
Modelling paradigm	Simulative prediction
Simulative prediction approach	Individual/cell-based (agents)
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Excel
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	Biomass values: foliage, stems, roots. Max. available

	soil water, initial stem number, stand age, max stand age, canopy quantum efficiency
Computational outputs	Biomass values: foliage, stems, roots. Max. available soil water, initial stem number, stand age, max stand age, canopy quantum efficiency
Example	

Model name	'FORESEE' - Forest Ecosystems in a Changing Environment	
Acronym	**4C**	Index 57
Web-link	http://www.pik-potsdam.de/~lasch/4c.htm	
Subject	Ecosystem	
	Vegetation including fungi	

Ecosystem service management Physical hazards

Description

It describes processes on tree and stand level basing on findings from eco-physiological experiments, long term observations and physiological modelling. The model uses tree and stand level variables to simulate tree species composition, forest structure, leaf area index as well as ecosystem carbon and water balances. Growth and mortality are described for tree cohorts as a group of identical trees concerning their tree characteristics (e.g. stem, leaf, and fine root biomass, height, diameter at breast height and at crown base, species type).

Model developer (name, e-mail)	
Modelling paradigm	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	
Operating system(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	

User_friendliness

Example Example Currently the model is parameterised for the five most abundant tree species of Central Europe (beech, Fagus sylvatica L.; Norway spruce, Picea abies L. Karst., Scots pine, Pinus sylvestris L., oaks, Quercus robur L., and Quercus petraea Liebl., and birch

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Model name Computer Program for the Identification and Simulation of Aquatic Systems

Acronym **AQUASIM** Index 170

Web-link http://www.aquasim.eawag.ch/

Subject Water, catchment

Ecosystem service management Physical hazards

Description

AQUASIM allows its users to define the spatial configuration of the system to be investigated as a set of compartments, which can be connected to each other by links. Currently, the available compartment types include mixed reactors, biofilm reactors (consisting of a biofilm and a bulk fluid phase), advective-diffusive reactors (plug flow reactors with or without dispersion), saturated soil columns (with sorption and pore volume exchange), river sections (describing water flow and substance transport and transformation in open channels) and lakes (describing stratification and substance transport and transformation in the water column of the lake and in adjacent sediment layers). Compartments can be connected by two types of links (lakes can not be linked to other compartments yet). Advective links represent water flow and advective substance transport between compartments, including bifurcations and junctions. Diffusive links represent boundary layers or membranes, which can be penetrated selectively by certain substances. The user of the program is free in specifying any set of state variables and transformation processes to be active within the compartments. For the model as defined by the user, the program is able to perform simulations, sensitivity analyses and parameter estimations using measured data. These features make the program a very useful research tool. Calculated results can be plotted to the screen (window interface version only), written to a

Model developer (name, e-mail)

Modelling paradigm ordinary andpartial differential equations

Simulative prediction approach regression

Vertical Complexity Software tool, packaging one or more formulae for

practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s) C++

Graphical mapping technology Non-GIS

Geographical applicability area Universal

Time horizon Short-term

Sectoral application area Research (descriptive)

User_friendliness Easy-to-use

User inputs inflow

Computational outputs

Example
http://www.eawag.ch/organisation/abteilungen/siam/software/aquasim/pdf/aquasim_manual.pdf

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Model name Decision Support system for sustainable development

Acronym **ATEH** Index 122

Web-link **Tõrge! Lubamatu hüperlingiviide.**

Subject Socio-environmental

Ecosystem service management Physical hazards

Description

ATEH is a Decision Support System software based on multicriterial decision models and multidimensional data analysis. It is designed to support decision making process in the textile industry regarding water pollution resulted from the specific technological processes.

- Is a complex software product providing interactive decision assistance for sustainable development

- Implements multicriterial decision patterns for parameterized and dynamic use.

- Provides optimal production schedules based on water pollution related restrictions

- Assists in coming to efficient decisions

Model developer (name, e-mail) Rădulescu Constanţa Zoe radulescu@ici.ro

Modelling paradigm

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name BALANCE

Acronym **BALANCE** Index

62

Web-link
http://www.scisoftware.com/environmental_software/product_info.php?products_id=

141&sessid=4a171308b13eb9a8d263ddf89c3447b5

Subject Water, catchment

Ecosystem service management Physical hazards

Description

Model for calculating mass transfer for geochemical reactions in ground water.Is designed to help define and quantify chemical reactions between ground water and minerals. The chemical composition of two waters must be known. Only the total concentrations of each element are required for models in which redox reactions are not considered. A phase represents a set of chemical elements that enter or leave the initial solution in fixed ratios.

Model developer (name, e-mail) info@scientificsoftwaregroup.com

Modelling paradigm	Simulative prediction
Simulative prediction approach	regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Visual Basic
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	Easy-to-use
User inputs	mass balance on elements, mixing end-member waters, oxidation-reduction reactions, simple isotope balance
Computational outputs	the moles of each phase, the stoichiometric coefficients, RS
Example	The Pan-Canadian Hydrology Modelling Tool - http://www.waterbalance.ca/

Model name	CABOTO	
Acronym	**CABOTO**	Index
		21
Web-link	http://staff.icar.cnr.it/spezzano/intercab/l2_res.htm	
Subject	Soil and rock	
Ecosystem service management	Physical hazards	

Description

The technique of in situ soil bioremediation employs bacteria to degrade chemical contaminats in areas of polluted soil. To predict and evaluate the results of field-scale operations, mathematical models describing the geological, chemical and biological phenomena occuring in the remediation process can be used.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name	Ecological Dynamics Model	
Acronym	**EcoDynamo**	Index 107
Web-link	https://bdigital.ufp.pt/dspace/bitstream/10284/826/3/ecodynamo.pdf	
Subject	Ecosystem Water, catchment	

Ecosystem service management Physical hazards

Description

EcoDynamo is an example of object oriented modelling software, built in C++ that was designed to simulate thermodynamic, hydrodynamic and biogeochemical processes of aquatic ecosystems. One important characteristic of this software is that its objects are compiled as Dynamic Link Libraries (DLLs) with an interface allowing their linkage with other modelling software codes written in FORTRAN or C. This allows different modelling teams to share software for the calculation of specific processes, independently of the programming language preferred, and enabling bidirectional code reutilisation. The EcoDynamo shell manages the graphical user interface, the communications between classes and the output devices, where the simulation results are saved. Simulated processes include:(i) hydrodynamics of aquatic systems – water elevations, current speeds and directions;(ii) thermodynamics - energy balances between water and atmosphere and water temperature;(iii) biogeochemical - nutrient and biological species dynamics;(iv) anthropogenic: e.g. biomass harvesting.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C++
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	
Time horizon	
Sectoral application area	
User_friendliness	
Example	Ria Formosa Lagoon is located in the south region of Portugal, in the Algarve province. The Ditty project

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Model name	European Soil Erosion Model	
Acronym	**EUROSEM**	Index 20

Web-link http://gcmd.nasa.gov/records/EUROSEM.html

Subject Soil and rock

Ecosystem service management Physical hazards

Description

Model for simulating erosion, transport and deposition of sediment over the land surface by interrill and rill processes. Simulates erosion on an event basis for fields and small catchments. It uses physical descriptions to describe the process of soil erosion and is fully dynamic.

Model developer (name, e-mail)	http://www.es.lancs.ac.uk/people/johnq/EUROS
Modelling paradigm	Simulative prediction
Simulative prediction approach	dynamic mass balance equation
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	DOS
Modelling language(s)	FORTRAN
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Research (descriptive)
User_friendliness	Expert assistance required
User inputs	Rainfall, temperature, plant leaf factor
Computational outputs	Total runoff, total soil loss, the storm hydrograph, the storm sediment graph

Example

Model name FEMMA

Acronym **FEMMA** Index

89

Web-link http://www.metla.fi/hanke/3383/femma/index-en.htm

Subject Water, catchment

Ecosystem service management Physical hazards

Description

To account for the most significant water and N fluxes in forested first-order catchments this, allowed evaluation of the effect of location of clear-cutting on stream water N export. The catchment was simplified into a two-dimensional hill slope extending from the water divide to the outlet. The FEMMA model combined FINNFOR, ROMULN, DEMA calculation tool for assessing catchment water and nitrogen fluxes. Nitrogen is calculated in ammonium, nitrate and dissolved organic nitrogen (DON) fractions.

Model developer (name, e-mail)	Lauren, Ari ari.lauren@metla.fi
Modelling paradigm	Simulative prediction
Simulative prediction approach	Process-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Management
User_friendliness	
User inputs	
Computational outputs	Runoff, Water balance components for the entire catchment, a forest compartment or a specific location in the catchment, Nitrate load and concentration in the outlet, Ammonium load and concentration in the outlet, DON load and concentration in the outlet, Nitrogen balance.
Example	

Model name GLOWA

Acronym **Glowa** Index

Web-link http://www.glowa.org/

Subject Soil and rock

Water, catchment

Ecosystem service management Physical hazards

Description

To calculate regional soil water, a modified Thornthwaite-Mather model has been built. Fed with regional soil data and state-of-the-art satellite rainfall and radiation products, daily soil water. GLOWA focuses on the problem of water availability. The aim of GLOWA is to develop simulation-tools and instruments which will allow to develop and to realize strategies for sustainable and future-oriented water management at regional level (river basins of approx. 100.000 km²), while taking into account global environmental changes and socioeconomic framework conditions. Consist different models: WISYS, STAR, SWIM, WBalMo, MONERIS, QSIM, REGE, LandUseScanner, RAUMIS, KaSIM.

Model developer (name, e-mail)	
Modelling paradigm	Multi-criteria analysis
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Region-specific
Time horizon	Long-term
Sectoral application area	Management
User_friendliness	Expert assistance required
Example	Within GLOWA five large cluster projects have been started. Two of them are located in Germany (Danube, Elbe), the others are investigating river catchment areas in North and West Africa (Drâa, Ouémé, Volta) as well as in the Middle East (Jordan).

Model name	Hydrological Simulation Program-Fortran
Acronym	**HSPF**

Index 8

Web-link
http://www.scisoftware.com/products/hspf_model_details/hspf_model_details.html

Subject	Water, catchment
Ecosystem service management	Physical hazards

Description

The HSPF model uses information such as the time history of rainfall, temperature and solar radiation; land surface characteristics such as land-use patterns; and land management practices to simulate the processes that occur in a watershed. Can simulate the watershed hydrology and associated water quality for both conventional and toxic organic pollutants on pervious and impervious land surfaces and in streams and well-mixed impoundments.

Model developer (name, e-mail)	info@scisoftware.com
Modelling paradigm	Simulative prediction
Simulative prediction approach	time series
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Fortran
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name LandClim

Acronym **LandClim** Index 65

Web-link http://e-collection.ethbib.ethz.ch/eserv/eth:27405/eth-27405-02.pdf

Subject Vegetation including fungi

Ecosystem service management Physical hazards

Description

Analyses the effect of topography, climate and land use on forest structure and dynamics. A particular focus is on large-scale natural disturbances like fire, wind throw, management. Modelled processes sensitive to climate. Spatially explicit (grid cell 30*30 m). LandClim calculates soil moisture availability using a simple bucket model. LandClim is based on an existing model (LANDIS), which incorporates a range of large-scale processes such as seed dispersal, wind and fire disturbances and harvesting, which dynamically interact with forest vegetation.

Model developer (name, e-mail)

Modelling paradigm	Optimization process
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Region-specific
Time horizon	Long-term
Sectoral application area	Management
	Research (descriptive)
User_friendliness	
Example	lake sediment paleobotanical reconstrions from Swiss Central Alps (Henne, 2008)

Model name Automated System for Evaluating and Management the Natural Soil Fertility

Acronym **MARISMA** Index 19

Web-link http://www.evenor-tech.com/microleis/microlei/microlei.aspx

Subject Wetland

Vegetation including fungi

Ecosystem service management Physical hazards

Description

Gives special emphasis to the soil chemical quality, but also considers several soil physical parameters related with the textural class.

Model developer (name, e-mail)	D. de la Rosa
Modelling paradigm	Simulative prediction
Simulative prediction approach	Qualitative
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name System of modelling the key mechanisms involved in the mobility of the heavy metals in the terrestrial

ecosystems and the wetlands

Acronym **MECOTER** Index

119

Web-link http://www.modelare-ecologica.ro/proiecte/mecoter/

Subject Ecosystem

Ecosystem service management Physical hazards

Description

Models about the bioaccumulation of metals in plant and their transfer to surface water and groundwater. 1. Application of Nonlinear Analysis Methods for Identifying Relationships Between a large set of soil chemical and physico-chemical parameters and 1a) the contamination of the groundwater 1b) the contamination of the flooding water 1c) the bioacumulation of metals in plants. 2. Models for the distribution and dynamic of the key control parameters of metals mobility in soil, as resulted from contribution 1. 3. Models for the dynamic of metals atmospheric deposition at the studied sites. 4. Simulation of the dynamic of athmospheric and hydrological control parameters of metals at the sites in the context of climatic changes. 5. Coherentized portfolio of models descring the biogeochemical processes. 6. Mechanisms explaining the nonlinear relationships between the key control parameters of metals mobility in soil and 1a) the contamination of the groundwater 1b) the contamination of the flooding water 1c) the bioacumulation of metals in plants.

Model developer (name, e-mail) aurora.neagoe@unibuc.ro

Modelling paradigm Simulative prediction

Simulative prediction approach regression

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name	Planning And Management Of Lakes And Reservoirs focusing on Eutrophication
Acronym	**Pamolare**
Index	174
Web-link	http://www.unep.or.jp/ietc/Pamolare/about_pamolare.asp
Subject	Water, catchment
Ecosystem service management	Physical hazards

Description

Eutrophication of freshwater bodies is a main environmental concern. Indicators of Eutrophication can include the following: accumulation of algal scum and toxins from algal blooms, infestations of species of aquatic plants, increased turbidity, incidence of water-related diseases, noxious odors, depletion of dissolved oxygen, and tainted fish and fish kills. Structurally Dynamic Model (SDM) is one type of models that simulates the eutrophication process and related species responses. It can also be used for restoration purposes or it can be adapted to wetland conditions. PAMOLARE II also considers species competition (macrophytes and phytoplankton) and interactions between macrophytes and macrophytes-feeding fish (cyprinid carps).

Model developer (name, e-mail)	International Lake Environment Committee
Modelling paradigm	Simulative prediction
Simulative prediction approach	regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use

User inputs

Computational outputs

Example PAMOLARE II is an SDM model that focuses on Shallow Lakes for advance eutrophication lake management.

Model name PnET

Acronym **PnET** Index 46

Web-link http://www.pnet.sr.unh.edu/

Subject Ecosystem

Ecosystem service management Physical hazards

Description

Is a suite of three nested computer models which provide a modular approach to simulating the carbon, water and nitrogen dynamics of forest ecosystems. For regional productivity and water balances, PnET has been run for each pixel of the 1 km resolution GIS data base.

Model developer (name, e-mail) Aber and Federer

Modelling paradigm Simulative prediction

Simulative prediction approach

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s) Visual Basic

Graphical mapping technology Raster-GIS (grids, pixels)

Geographical applicability area

Time horizon Long-term

Sectoral application area

User_friendliness

Example

1. To run PnET regionally to predict potential forest productivity under current and double CO_2 conditions for Ireland.

2. PnET has been used in conjunction with estimates of canopy chemistry obtained by high resolution remote sensing for the Prospect Hill tract at Harvard Forest .

Model name River and Stream Water Quality Model

Acronym **QUAL2K** Index 170

Web-link http://www.epa.gov/athens/wwqtsc/html/qual2k.html

Subject Water, catchment

Ecosystem service management Physical hazards

Description

•Model segmentation. Q2E segments the system into river reaches comprised of equally spaced elements. In contrast, Q2K uses unequally-spaced reaches. In addition, multiple loadings and abstractions can be input to any reach.

•Carbonaceous BOD speciation. Q2K uses two forms of carbonaceous BOD to represent organic carbon. These forms are a slowly oxidizing form (slow CBOD) and a rapidly oxidizing form (fast CBOD). In addition, non-living particulate

organic matter (detritus) is simulated. This detrital material is composed of particulate carbon, nitrogen and phosphorus in a fixed stoichiometry.

•Anoxia. Q2K accommodates anoxia by reducing oxidation reactions to zero at low oxygen levels. In addition, denitrification is modeled as a first-order reaction that becomes pronounced at low oxygen concentrations.

•Sediment-water interactions. Sediment-water fluxes of dissolved oxygen and nutrients are simulated internally rather than being prescribed. That is, oxygen (SOD) and nutrient fluxes are simulated as a function of settling particulate organic matter, reactions within the sediments, and the concentrations of soluble forms in the overlying waters.

•Bottom algae. The model explicitly simulates attached bottom algae.

•Light extinction. Light extinction is calculated as a function of algae, detritus and inorganic solids.

Model developer (name, e-mail)

Modelling paradigm	Simulative prediction
Simulative prediction approach	regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	VBA
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name Quantitative Evaluation of the Fertility of Tropical Soils

Acronym **QUEFTS** Index 18

Web-link http://www.prem-online.org/index.php?p=publications&a=show&id=108

Subject Vegetation including fungi

Soil and rock

Ecosystem service management Physical hazards

Description

Quantitatively estimate optimal fertilizer requirements to alleviate the problems of the crops. Was used to estimate region-specific nitrogen (N), phosphorus (P) and potassium (K) requirements as well as fertilizer applications needed to realize target yields of wheat and maize. QUEFTS predicts crop yields from chemical soil characteristics, assuming all other production factors are optimal. While the assumption may not be realistic, QUEFTS can still be used as an indicator of soil fertility.

Model developer (name, e-mail)	Ingrid Mulder
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
User inputs	Internal nutrient efficiencies, N, K
Computational outputs	
Example	China, India, Benin

Model name Riparian Ecosystem Management Model

Acronym **REMM** Index 199

Web-link http://www.tifton.uga.edu/remmwww/

Subject Water, catchment

Ecosystem

Ecosystem service management Physical hazards

Description

The Riparian Ecosystem Management Model (REMM) is a computer simulation model.

REMM is used to simulate hydrology, nutrient dynamics and plant growth for land areas between the edge of fields and a water body. Output from REMM will allow designers to develop buffer systems to help control non-point source pollution. REMM simulates hydrologic, carbon and nutrient cycling, and plant growth processes in riparian forest systems on a daily time step (Lowrance et.al., 1998). The results of the simulations are the model output, which are the operational characteristics of riparian buffer systems.

Model developer (name, e-mail)	Randy Williams randy@tifton.cpes.peachnet.edu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C++
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Research (descriptive)
	Management
User_friendliness	Easy-to-use
User inputs	weather, itter and three soil layers, plant growth that occur in each zone, vertical and horizontal subsurface, carbon and nutrient dynamics
Computational outputs	characteristics of riparian buffer systems
Example	

Model name	Retention Curve Program for Unsaturated Soils	
Acronym	**RETC**	Index 6
Web-link	http://www.scisoftware.com/	
Subject	Ecosystem	

	Soil and rock
Ecosystem service management	Physical hazards

Description

RETC is a computer program which may be used to analyze the soil water retention and hydraulic conductivity functions of unsaturated soils. These hydraulic properties are key parameters in any quantitative description of water flow into and through the unsaturated zone of soils. Uses the parametric models of Brooks-Corey and Genuchten to represent the soil water retention curve and the theoretical pore-size distribution models of Mualem and Burdine to predict the unsaturated hydraulic conductivity function from observed soil water retention data. A nonlinear least-squares parameter optimization method is used to estimate the unknown coefficients in the hydraulic models. The program may be used to fit several analytical models to observed water retention and/or unsaturated hydraulic conductivity data. The model incorporates menu-driven data entry.

Model developer (name, e-mail)	tech@gwsoftware.com
Modelling paradigm	Simulative prediction
Simulative prediction approach	regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	Easy-to-use
User inputs	water flow into the unsaturated zone, water flow through the unsaturated zone
Computational outputs	the hydraulic conductivity
Example	

Model name Stochastic Analysis, Modelling and Simulation

Acronym **SAMS** Index 85

Web-link http://www.usbr.gov/pmts/hydraulics_lab/software/hyd_software.html

Subject Water, catchment

Ecosystem service management Physical hazards

Description

For the water supply modelling, the monthly changes are applied to the monthly Stochastic Analysis and Modelling System (SAMS) time-series

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach Time series

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology Non-GIS

Geographical applicability area

Time horizon

Sectoral application area

User_friendliness

Example

Model name Soil parameter Estimation

Acronym **SOIL** Index 10

Web-link http://www.trentu.ca/academic/aminss/envmodel/models/Soil3.html

Subject	Soil and rock
Ecosystem service management	Physical hazards

Description

Was developed to simulate water and heat processes in soils. The Soil model gives a very simple assessment of the relative potential for reaction, degradation and leaching of a pesticide applied to a surface soil. Chemical partitioning between the air, water, organic matter, and mineral matter phases in a single layer of soil is calculated as a function of physical chemical properties. Roots are included as a fraction of the soil volume and are assumed to be at equilibrium with the other phases of the soil. This model gives an estimate of the rates of volatilization, leaching, and degradation from the soil. These rates are then used to estimate half-times for losses by these processes, and the overall half-time. The model is not dynamic in nature, it presents the steady-state condition and fluxes and infers the likely times associated with these loss processes.

Model developer (name, e-mail)	Per-Erik.Jansson@aom.kth.se
Modelling paradigm	Simulative prediction
Simulative prediction approach	regression
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	basic
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Research (descriptive)
User_friendliness	Easy-to-use
User inputs	Soil properties, chemical properties, dosage
Computational outputs	All input data, fugacity of the soil, Z values for all phases, amounts and concentrations for all phases , D values, and fluxes for all processes, a summary diagram

Example

Model name STELLA

Acronym **STELLA** Index

79

Web-link http://www1.union.edu/rices/STELLA/stella_intro.html

Subject Economic

Ecosystem service management Physical hazards

Description

How does climate change influence an ecosystem over time? How do oil prices respond to shocks in supply and/or demand? What will happen when the ozone layer is gone? Systems Thinking software like STELLA offers an opportunity to create visual models that actively engage students to study a wide variety of problems. How do basic macroeconomic principles affect income and consumption? Students report that the modelling helps them understand complex processes like photosynthesis by helping them visualize and explore how the various parts of the process interact.

Model developer (name, e-mail)	Steven K. Rice rices@union.edu
Modelling paradigm	Optimization process
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Education Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name	SWAP	
Acronym	**SWAP**	Index 11
Web-link	http://www.swap.alterra.nl/	
Subject	Water, catchment Ecosystem Soil and rock	

Ecosystem service management Physical hazards

Description

The ecosystem model is designed to simulate flow and transport processes at field scale level, during growing seasons and for long term time series. Keywords: water management, crop production, solute transport, soil water flow, bypass flow, soil shrinkage, soil cracking, crack flow, preferential flow, hydraulic functions, hysteresis, heat dynamics, solute dynamics, evaporation, irrigation scheduling, drainage

Model developer (name, e-mail)	swap.alterra@wur.nl
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based - Richards equation
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	DOS
Modelling language(s)	Fortran
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	
Computational outputs	

User inputs	Daily meteorological input data, Soil water flow, Soil heat flow, Solute flow, Crop growth
Computational outputs	3-day prediction of water demand, Demonstrate impact of different soils on irrigation demand, Analyse leaching potentials
Example	Typical examples are given by Van Dam et al. (2008) for: 1. Field scale water and salinity management 2. Irrigation scheduling 3. Transient drainage conditions 4. Plant growth affected by water and salinity 5. Pesticide leaching to ground water 6. Regional drainage from topp soils towards different surface water systems 7. Optimization of surface water management 8. Effects of soil heterogeneity

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Model name Soil and Water Integrated Model

Acronym **SWIM** Index

1

Web-link
http://www.scisoftware.com/environmental_software/product_info.php?products_id=

98

Subject Water, catchment

Ecosystem service management Physical hazards

Description

Soil water infiltration and movement model - simulate water balances

Assumptions:

1. Conditions can be treated as horizontally uniform,

2. Flow is described by Richards' equation,

3. Soil hydraulic properties can be described simply.

The program solves the nonlinear water balance equations used to approximate Richards' equation by an iterative method that uses sets of simultaneous linear equations. Execution time is proportional to this value. SWIM integrates the relevant eco-hydrological processes including water flow, nutrient transport and turn-over, vegetation (crop) growth and land use and water management needed to investigate climate and land use change impacts on hydrological systems and vegetation at the regional scale. It was developed to investigate impacts of land use and climate changes on hydrology and vegetation (crop yields).

Model developer (name, e-mail)	tech@gwsoftware.com and hattermann@pik- potsdam.de
Modelling paradigm	Simulative prediction
Simulative prediction approach	Richards' equation
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Fortran
Graphical mapping technology	Raster-GIS (grids)
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	Management
User_friendliness	Expert assistance required
User inputs	Soil depth, ranoff parameters, vegetation types, precipitation- and evaporation data, land use, climatic
Computational outputs	Evaporation rates, water balance, values of soil water potential, volumetric water content, soil hydraulic conductivity, soil water flow rate
Example	

Model name	Storm Water Management Model

Acronym **SWMM** Index 9

Web-link http://www.epa.gov/ednnrmrl/models/swmm/index.htm

Subject Water, catchment

Ecosystem service management Physical hazards

Description

Is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads.

Model developer (name, e-mail)	rossman.lewis@epa.gov
Modelling paradigm	Simulative prediction
Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	C
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	
User_friendliness	Easy-to-use
User inputs	surface roughness, flow path length, Horton: max/min rates and decay constant, hydraulic conductivity, initial moisture deficit and suction head, Curve number
Computational outputs	the surface runoff
Example	Typical applications include: 1. Design and sizing of drainage system components for flood control 2. Sizing of detention facilities and their appurtenances

for flood control and water quality protection

3. Flood plain mapping of natural channel systems

Model name Surface Water (Hydrology) Study Site Metadata

Acronym **Swssm** Index

5

Web-link http://www.epa.gov/ceampubl/ceamhome.htm

Subject Soil and rock

Water, catchment

Ecosystem service management Physical hazards

Description

A soil water storage simulation model (SWSSM) was developed to calculate daily soil water storage and corresponding evapotranspiration and deep percolation as a function of water delivery flexibility for a vineyard in California. Adjustment for extremes in weather is not possible. For analysis of quantity and quality problems associated with urban runoff.

Model developer (name, e-mail)

Modelling paradigm Simulative prediction

Simulative prediction approach

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform

Operating system(s)

Graphical mapping technology

Geographical applicability area

Time horizon Short-term

Sectoral application area

User_friendliness

User inputs range of irrigation time, furrow inflow rate

Computational outputs

Example

Model name The Terrestrial Ecosystem Model

Acronym **TEM** Index 163

Web-link http://www.mbl.edu/eco42/

Subject Atmosphere including weather

Ecosystem

Ecosystem service management Physical hazards

Description

The Terrestrial Ecosystem Model (TEM) is a process-based ecosystem model that describes carbon and nitrogen dynamics of plants and soils for terrestrial ecosystems of the globe. The TEM uses spatially referenced information on climate, elevation, soils, vegetation and water availability as well as soil- and vegetation-specific parameters to make monthly estimates of important carbon and nitrogen fluxes and pool sizes of terrestrial ecosystems. The TEM operates on a monthly time step and at a 0.5 degrees latitude/longitude spatial resolution. Improvements in computer resources have allowed us to examine ecosystem processes across the globe in more detail over time so that several versions of TEM have been developed over the past decade. At first, TEM only conducted equilibrium analyses of terrestrial carbon and nitrogen dynamics with hydrological inputs determined by an independent water balance model (WBM, Vörösmarty et al., 1989). This WBM used the same climatic data and soil-specific parameters as TEM. In version 4.0, the algorithms of the WBM were incorporated directly into TEM so that terrestrial carbon, nitrogen and water variables were determined concurrently. Then, we were then able to develop TEM 4.1 using relatively minor modifications of TEM 4.0 so that the model could conduct either equilibrium or transient analyses of terrestrial carbon and nitrogen dynamics.

Model developer (name, e-mail)

Modelling paradigm Optimization process

Vertical Complexity Software tool, packaging one or more formulae for practical use

Computing platform Single computer/PDA

Operating system(s) Microsoft (Windows, Silverlight, .net etc)

Modelling language(s)

Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	
User_friendliness	
User inputs	clamate, elevation, soils, vegetation and water availability as well as soil- and vegetation-specific parameters
Computational outputs	estimates of important carbon and nitrogen fluxes and pool sizes of terrestrial ecosystems
Example	

Model name	TREEDYN3	
Acronym	**TREEDYN3**	Index
		54
Web-link	http://www.helmholtz-muenchen.de/	
Subject	Vegetation including fungi	
	Soil and rock	
Ecosystem service management	Physical hazards	
Description		

TREEDYN3 is a process model for tree growth, carbon and nitrogen dynamics in a single-species, even-aged forest stand. The tree/soil system is described by a set on nonlinear ordinary differential equations for the state variables: tree number, base diameter, tree height, leaf mass, fine root mass, fruit biomass, assimilate, carbon and nitrogen in litter, soil and organic matter, and plant available nitrogen. It includes explicit formulations of all relevant ecophysiological processes such as computation of radiation as a function of seasonal time and daytime, light attenuation in the canopy, and canopy photoproduction as a function of latitude, seasonal time and daytime, respiration of all parts, assimilate allocation, increment formation, nitrogen fixation, mineralization, humification and leaching, forest management, temperature effects on respiration.TREEDYN3 was parametrized for European tree species (Picea abies, Pinus sylvestris, Pinus pinaster, Quercus ilex, Fagus sylvatica) and applied on a number of sites throughout Europe to questions of long-term impacts of climate change on carbon dynamics and forest stand growth (EU-project LTEEF). The nitrogen fertilization effect on stand growth caused by increased nitrogen deposition was evaluated for the Solling F1-site.

Model developer (name, e-mail)	
Modelling paradigm	ordinary differential equations
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Unix, Linux or other Unix-like
Modelling language(s)	Pascal, C++
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Short-term
Sectoral application area	Research (descriptive)
User_friendliness	
User inputs	tree number, base diameter, tree height, wood biomass, nitrogen in wood, leaf mass, fine root mass, fruit biomass, assimilate, carbon and nitrogen in litter, carbon and nitrogen in soil organic matter, and plant-available nitrogen.
Computational outputs	crown projection area
Example	

Models of Risk assessment

Model name Real Options

Acronym **Real Options** Index

43

Web-link http://en.wikipedia.org/wiki/Real_options_analysis

Subject Economic

Ecosystem service management Risk assessment

Description

A numerical analysis approach used in economics to inform decisions with irreversible consequences that affect a real asset. Monte Carlo simulation must be used together with some optimization method

Model developer (name, e-mail)	Dixit and Pindyck
Modelling paradigm	Simulative prediction
Simulative prediction approach	Monte Carlo
Vertical Complexity	Published statistical relationship (regression, rate or other formula)
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Modelling language(s)	Visual Basic
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	Not specified
Sectoral application area	Management
User_friendliness	Easy-to-use
User inputs	
Computational outputs	
Example	

Model name	MY-X	
Acronym	**MY-X**	Index 97
Web-link	http://my-x.hu	
Subject	Water, catchment Fauna Vegetation including fungi Soil and rock Ecosystem Economic Atmosphere including weather Social & institutional	

Socio-environmental

Ecosystem service management Risk assessment

Description

http://miau.gau.hu/myx-free/index.php3?x=i0

http://miau.gau.hu/myx-free/index.php3?x=t01

http://miau.gau.hu/myx-free/index_e9.php3?x=e09

The My-X tool is attempting to provide online data mining services for each decision maker instead of being always intuitive/heuristic with the risk of instability and mistake or instead of using well known data mining tools which cause unacceptable cost (through system administration, servers, analysts, licenses, etc.). The first generation of this online tool provides (as a core method) the similarity analysis, which can be interpreted parallel as a special decision tree, an artificial neural network, benchmarking tool, price/performance optimizer or online expert system: (to say) an universal strategy for interpretation of arbitrary phenomena. The similarity analysis needs only one object-attribute-matrix (OAM) as learning pattern. There are a huge number of parameters, in order to be more efficient. Through the provided advising tools you will know about the parameter setting.The following conversation is to determine if all necessary preconditions are met in order to use the COCO-online standard additive procedure. If not, instructions will be given to help decide which procedure to choose. All your

Model developer (name, e-mail)	Pitlik (László) pitlik@miau.gau.hu
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule based
	Regression
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
	Unix
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	
Sectoral application area	Research
	Management
	Education and learning

User_friendliness	
User inputs	attribute-matrix (=learning pattern)
Computational outputs	graphs, expert system (combinatorical space)
Example	Monitoring rural development strategies, variant-analysis, forecasting

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Models of Water management

Model name	PolFlow	
Acronym	**PolFlow**	Index 99
Web-link	http://www.dsi.gov.tr/english/congress2007/chapter_3/93.pdf	
Subject	Water, catchment	
Ecosystem service management	Water management	

Description

The PolFlow model is embedded in PCraster, a raster based GIS modelling tool [De Wit, 1999]. The model contains three factors that are seen as determinant to describe water fluxes [Greffe, 1999]. The long term average total runoff, the groundwater recharge index, and the groundwater residence time are the determinant factors in the model.

Model developer (name, e-mail)	
Modelling paradigm	Simulative prediction
Simulative prediction approach	Rule-based
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	Universal
Time horizon	Long-term
Sectoral application area	Research (descriptive) Management

User_friendliness

User inputs	Average annual precipitation and temperature, hydrogeological map, digital Elevation Model, Slope, land cover, soil map, Discharge data for rivers.
Computational outputs	Quantity of surface and groundwater. Nutrient transport (nitrogen, phosphorus) in the drainage basin. Average total runoff or precipitation surplus

Example

Model name MY-X

Acronym **MY-X** Index 97

Web-link http://my-x.hu

Subject Water, catchment

Fauna
Vegetation including fungi
Soil and rock
Ecosystem
Economic
Atmosphere including weather
Social & institutional
Socio-environmental

Ecosystem service management Water management

Description

http://miau.gau.hu/myx-free/index.php3?x=i0

http://miau.gau.hu/myx-free/index.php3?x=t01

http://miau.gau.hu/myx-free/index_e9.php3?x=e09

The My-X tool is attempting to provide online data mining services for each decision maker instead of being always intuitive/heuristic with the risk of instability and mistake or instead of using well known data mining tools which cause unacceptable cost (through system administration, servers, analysts, licenses, etc.). The first generation of this online tool provides (as a core method) the similarity analysis, which can be interpreted parallel as a special decision tree, an artificial neural network, benchmarking tool, price/performance optimizer or online expert system: (to say) an universal strategy for interpretation of arbitrary phenomena. The similarity analysis needs only one object-attribute-matrix (OAM) as learning pattern. There are a huge number of parameters, in order to be more efficient. Through the provided advising tools you will know about the parameter setting.The following conversation is to determine if all necessary preconditions are met in order to use the COCO-online standard additive procedure. If not, instructions will be given to help decide which procedure to choose. All your

Model developer (name, e-mail)	Pitlik (László) pitlik@miau.gau.hu
Modelling paradigm	Simulative prediction
Simulative prediction approach	
Simulative prediction	
Simulative prediction approach	approach Rule based
	Regression
Vertical Complexity	Decision support system, organizing or enabling several modelling tools
Computing platform	Internet-linked Servers
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
	Unix
Graphical mapping technology	Non-GIS
Geographical applicability area	Universal
Time horizon	
Sectoral application area	Research
	Management
	Education and learning
User_friendliness	
User inputs	attribute-matrix (=learning pattern)
Computational outputs	graphs, expert system (combinatorical space)
Example	Monitoring rural development strategies, variant-analysis, forecasting

Models of Wild vegetal products

Model name	Forest landscape disturbance, Management, and Succession

Acronym **LANDIS** Index

64

Web-link http://e-collection.ethbib.ethz.ch/eserv/eth:27405/eth-27405-02.pdf

Subject Ecosystem

Ecosystem service management Wild vegetal products

Description

In general simulate broad-scale (>105 ha) landscape dynamics, including succession, disturbance, seed dispersal, forest management, and climate change effects. Landis would estimate fire risk by accounting for the interactions among vegetation-management treatments, forest succession, natural disturbance, and hunamcaused ignitoins, cannot predict the expansion of human populations through time.

Model developer (name, e-mail)	heh@missouri.edu
Modelling paradigm	Simulative prediction
Simulative prediction approach	
Vertical Complexity	Software tool, packaging one or more formulae for practical use
Computing platform	Single computer/PDA
Operating system(s)	Microsoft (Windows, Silverlight, .net etc)
Graphical mapping technology	Raster-GIS (grids, pixels)
Geographical applicability area	
Time horizon	Long-term
Sectoral application area	
User_friendliness	
Example	

References

Argent, R.M., Houghton, B., 2001. Land and water resources model integration: software engineering and beyond. Advances in Environmental Research 5: 351-359.

Commons, M.L., Trudeau, E.J., Stein, S.A., Richards, F.A., Krause, S.R. 1998. Hierarchical complexity of tasks shows the existence of developmental stages. Developmental review. 18: 237-278.

Derry, J.F., 1998. Modelling ecological interaction despite object-oriented modularity. Ecological modelling 107: 145 – 158.

Hawken, P., Lovins, A., Lovins, H., 1999. Natural capitalism: creating the next industrial revolution. Little, Brown and Company. 416 pp.

Hodder, K.H., Sharp, R.J.A., Perrella, L., Butters, J., Kenward, R.E. & Ewald, J. 2009. Synthesis report: Central and local information flows and decision making requirements. Report to the European Commission from FP7 Project #212304 (Transactional Environment Support System).

Hofman, D., 2005. LIANA Model Integration System – architecture, user interface design and application in MOIRA DSS. Advances in Geosciences 4: 9-16.

Jörgensen, S.E., Bendoricchio, G. 2001. Fundamentals of ecological modelling (third ed.), Elsevier, Oxford. 480 pp.

Kenward,, R.E., Ewald, J. .& Sharp, R.J.A., 2010. Report on pan-European survey of assessment processes. Report to the European Commission from FP7 Project #212304 (Transactional Environment Support System).

Koestler, A. 1967. The ghost in the machine. Penguin Group. 400 pp.

Moore, R.V., Tindall, I., 2005. An overview of the Open Modelling Interface and Environment (the OpenMI). Environmental Science and Policy 8: 279 – 286.

Piirimäe, Kr. 2011. Provision of decision support in environmental management. Int. J. Sustainable Society. X: xxxx.

Poch, M., Comas, J., Rodriguez-Roda, I., Sanchez-Marre, M., Cortes, U., 2004. Designing and building real environmental decision support systems. Environmental Modelling & Software, 19: 857-873.

Pretzsch, H., Utschig, H., Sodtke, R. Applications of tree growth modelling in decision support for sustainable forest management.

Robinson, A.P., Ek, A.R., 2003. Description and validation of a hybrid model of forest growth and stand dynamics for the Great Lakes region. Ecological modelling, 170: 73-104.

Sturtevant, B.R., Fall, A., Kneeshaw, D.D., Simon, N.P.P., Papaik, M.J., Berninger, K., Doyon, F., Morgan, D.G., Messier, Cr. 2007. A toolkit modeling approach for sustainable forest management planning: achieving balance between science and local needs. Ecology and society 12(2): 7.

Walker, D.H., 2002. Decision support, learning and rural resource management. Agricultural Systems 73: 113-127.