ECOMOD

Content

About ISEM

The International Society for Ecological Modelling (ISEM) promotes the international exchange of ideas, scientific results, and general knowledge in the area of the application of systems analysis and simulation in ecology and natural resource management. The Society was formed in Denmark in 1975, and today has chapters in Germany, Italy, Japan, and North America. ISEM Sponsors conferences, symposia, and workshops that promote the systems philosophy in ecological research and teaching, and in the management of natural resources. The Society publishes the newsletter ECOMOD, and its members frequently contribute articles to the official scientific journal of the Society, *Ecological Modelling*.

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Tian Xiang Yue and Cheng Hu Zhou

Research scientists
State Key Laboratory of Resources and
Environmental Information System,
Chinese Academy of Sciences
917 Building, Datun, Anwai
100101 Beijing, P. R. China

E-mail: yue@www.Ireis.ac.cn

An Approach of Differential Geometry to Data Mining

Abstract

A differential geometry approach is proposed to give a solution to the problems facing data mining. Based on plane curve theorems of differential geometry, a mathematical model formulating distance between plane curves is constructed, in which the distance is determined by at most three variables. This kind of distance is a distance on metric space of curve according to the theory of functional analysis. Finally, a model for huge-data in a single-attribute-phase and a model for huge-indices in a multi-attribute-phase are constructed, which are based on the mathematical model formulating distance between curves. The approach of differential geometry to data mining includes three important steps relevant the overall purpose of data mining: preparing data, operating models, and evaluating model results.

Key words: Data mining, Differential geometry, Mathematical models, Attribute phase.

1. Introduction

For the last few years, both the number and size of databases have been growing at a staggering rate. It has been recognized that there is valuable knowledge buried in the data. In the meantime, some of the enabling technologies have recently become mature enough to make data mining usable for large data sets (Carbone, 1998). Therefore, data mining has received increased attention and is becoming popular due to the decreasing costs of data collection (Pfeiffer, 1998).

Data mining is defined as the process of extracting patterns and relationships, often previously unknown, from data sources that include data bases, collection data, or even data warehouse (Thuraisingham, 1997). Data mining is a step in a larger process of knowledge discovering in data bases (KDD) that refers to the overall process of discovering useful knowledge from data. To begin the KDD process, the analysis must first have an overall purpose or set of goals to select data to be analyzed from the set of all available data. Then, the target data are moved to another database for further preprocessing. To discover knowledge such as trends, patterns, characteristics and anomalies, data mining algorithms should be used, which should be pertinent to the purpose of the analysis and to the type of data to be analyzed. When a pattern is identified, it should be examined to determine whether it is new, relevant and correct by some standard of measure. After the interpretation and evaluation step is completed and the pattern is deemed relevant and useful,

Data mining is an important method for extracting valuable information from all sizes of databases. Data miners are sometimes required to construct a highly accurate model for data mining as quickly as possible. But three factors make constructing a model for data mining a potentially lengthy process: (1) the enormous amount of data that must be processed, (2) the large number of models that must be constructed, and (3) the intricacies of testing and validating models (Small and Edelstein, 1998). The approach of differential geometry, developed in this paper, is a solution to these problems. This approach to data mining includes a model for huge data in a single attribute phase and a model for huge indices in a multi attribute phase.

2. The Foundation of the Approach

The approach is based on the Curve Theorem in the plane (Spivak, 1979). Let $k : [S_0, S] \to \Re$ be continuous. Then there is a curve, $L : [S_0, S] \to \Re^2$, parameterized by arc-length, whose curvature at s is $k(s)$ for all $s \in [S_0, S]$. Moreover, if L_1 and L_2 are two such curves, then $L_1 = \alpha L_2$ where α is some proper Euclidean motion (a translation followed by a rotation).

Therefore, the overall difference between the two plane curves can be simulated as following (Yue, 1990):

$$(1) \quad CD = \frac{1}{S - S_0} \int_{S_0}^{S} \left(\begin{array}{c} \left(L_1(S_0) - L_2(S_0)\right)^2 + \\ \left(a_1'(s) - a_2'(s)\right)^2 + \\ \left(k_1(s) - k_2(s)\right) \end{array} \right)^2 ds$$

Where $k_i(s)$ is the curvature of the plane curve L_i; $a_i(s)$ is the slope of the plane curve L_i; $L_i(S_0)$ is the initial value (i=1,2).

It can be demonstrated that $CD(L_1, L_2)$ has the following three properties (Yue et al. 1990):

(a) $CD(L_1, L_2) \geq 0$; $CD(L_1, L_2) = 0$ if and only if $L_1 = L_2$;

(b) $CD(L_1, L_2) = CD(L_2, L_1)$;

(c) $CD(L_1, L_3) \leq CD(L_1, L_2) + CD(L_2, L_3)$

In terms of Theory of Functional Analysis, $CD(L_1, L_2)$ is a kind of distance on metric space of curves (Taylor, 1958). We could call this kind of distance a Curves' Distance.

If the curves L_i could be simulated as:

$$(2) \quad y = f_i(x)$$

then, a_i and k_i can be respectively formulated as

$$(3) \quad a_i(x) = \frac{df_i(x)}{dx}$$

$$(4) \quad k_i(x) = \frac{d\alpha_i(x)}{dx} \cdot \left(1 + \alpha_i^2(x)\right)^{-\frac{3}{2}}$$

$$(5) \quad ds = \left(1 + \alpha^2(x)\right)^{\frac{1}{2}} dx$$

Suppose that the curve $L_2 : f(x)$ is considered as an intended-goal-function and $L_1 : g(x)$ is an arbitrary function. According to the discussion above, if $g(x)$ consists of negative factors, the intended-goal-function is a plane straight line $f(x) = 0$, $x \in [X_0, X]$ In this case, $\tau_2(s)$. $\kappa_2(s)$, $\alpha_2(s)$ and $f(x_0)$ equal zero, then (Yue, 1994):

$$(6) \quad CD_{negative} = -\frac{1}{X - X_0} \int_{X_0}^{X} (a^2(x) + \hat{e}^2(x) + g^2(X_0))$$

$$(1 + a^2(x))^{\frac{1}{2}} dx$$

Obviously, $CD_{negative} \leq 0$; $CD_{negative} = 0$ is the optimum situation. In other words, the closer the distance is from the $f(x) = 0$, the better the situation is.

If $g(x)$ consists of positive factors, it is not so easy to determine a quantitatively intended goals. In this situation, we express the intended-goal-function as the longer distance from the straight line $f(x) = 0$. In other words, for the issues of positive factors, the better the situation is, the longer the distance is from the straight line $f(x)=0$. The model can be generally formulated as

$$(7) \quad CD_{positive} = \frac{1}{X - X_0} \int_{X_0}^{X} \left(\frac{a^2(x) + k^2(x) +}{g^2(X_0)} \right) \left(1 + \frac{1}{a^2(x)} \right)^{\frac{1}{2}} dx$$

Where $CD_{positive} \geq 0$; $CD_{positive} = 0$ is the worst situation and the biggest $CD_{positive}$ is the optimum situation.

3. The Model for Huge-Data in a Single-Attribute-Phase

If the relative data at every point of the earth or of a region are ordered in terms of longitude, latitude and time, they are sequenced in three dimensions. The train of thought in this model at the initial stage of its development can be expressed as follows: (1) at first, let two of the three variables (longitude, latitude and time) be fixed temporally; sequenced data are transformed into plane curves; for any plane curve, it is enough to analyze three parameters that are intercept, slope and curvature to find the pattern of the sequenced data; (2) in order to analyze the reasons that have caused the pattern, matrices of leading factors are included in the model; (3) finally, the temporarily fixed variables are respectively allowed to change freely so that we can analyze the spatial and temporal dynamics.

Suppose that the sequenced data in single-attitude-phase can be expressed as fellows in terms of longitude, latitude and time,

$$(8) \quad X(t) = \begin{bmatrix} x(1,1,t) & x(1,2,t) & ... & x(1,J,t) \\ x(2,1,t) & x(2,2,t) & ... & x(2,J,t) \\ ... & ... & ... & ... \\ x(I,1,t) & x(I,2,t) & ... & x(I,J,t) \end{bmatrix} = [x(i,j,t)]_{I \times J}$$

where $X(t)$ is the tth layer of the three-dimensional matrix, $t=1,2,...,T...,J$ is the maximum longitude; I is the maximum latitude and T is the maximum value of the time variable.

The three-dimensional matrix X(t) can be transformed into a standardized matrix

$$(9) \quad Y(t) = [y(i,j,t)]_{I \times J}$$

where

$$(10) \quad y(i,j,t) = \frac{x(i,j,t)}{x_{max}}$$

$$(11) \quad x_{max} = \max_{i,j,t} \{x(i,j,t)\}$$

Then, the dynamic model in terms of latitude and time can be formulated as

$$(12) \quad CD(i,t) = sign(y) \cdot \frac{1}{J} \sum_{j=1}^{J} \left(\begin{pmatrix} a^2(i,j,t) + \\ k^2(i,j,t) + \\ y^2(i,0,t) \end{pmatrix} \left(1 + a^2(i,j,t) \right)^{\frac{1}{2}} \right)$$

where

$$(13) \quad sign(y) = \begin{cases} -1 & y < 0 \\ 1 & y > 0 \end{cases}$$

$$(14) \quad y(i,0,t) = \frac{1}{J} \sum_{j=1}^{J} y(i,j,t)$$

$$(15) \quad \alpha(i,j,t) = y(i,j,t) - y(i,j-1,t)$$

$$(16) \quad k(i,j,t) = (\alpha(i,j,t) - \alpha(i,j-1,t))(1 + \alpha^2(i,j,t))^{-\frac{3}{2}}$$

$$(17) \quad \alpha(i,0,t) = \frac{1}{J} \sum_{j=1}^{J} \alpha(i,j,t)$$

$$(18) \quad k(i,0,t) = \frac{1}{J} \sum_{j=1}^{J} k(i,j,t)$$

To formulate the dynamic state of the leading factors, we introduce two special matrixes,

$$(19) \quad S_{max}(t) = (M(i,j,t))_{I \times J}$$

$$(20) \quad S_{min}(t) = (m(i,j,t))_{I \times J}$$

where

$$(21) \quad M(i,j,t) = \begin{cases} x(i,j,t) & x(i,j,t) \geq D_1 \\ 0 & x(i,j,t) < D_1 \end{cases}$$

$$(22) \quad m(i,j,t) = \begin{cases} 0 & x(i,j,t) > D_2 \\ x(i,j,t) & x(i,j,t) \leq D_2 \end{cases}$$

$D_1 > D_2$; D_1 is the critical upper-value and D_2 is the critical lower-value.

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According to requirements of some studied issues, very useful knowledge can sometimes be obtained by analyzing the dynamic characteristics of the sector $\left(\bar{y}, \alpha\left(i, j, t\right) k\left(i, j, t\right)\right)$, where $\bar{y}$ is the measurements of average situation of the huge-data in a single-attribute-phase.

4. The Model for Huge-Indices in a Multi-Attribute-Phase

Index systems have been studied by many scientists, in which each index is a summary of a data cluster. The Organization for Economic Co-operation and Development (OECD) developed a set of environmental indicators for agriculture in terms of the Driving Force-State-Response (DSR) framework in order to identify and quantify the extent of the impacts of agriculture and agricultural policies on the environment and to better understand the effects of different policy measures on the environment (OECD, 1997). Haber and Engelfried (1997) set up a criterion system for environmental impact assessment to establish ecological balance-sheets and measures of environmental protection. The World Bank (1996) developed social indicators of development to address the most pressing issue facing the World Bank and its member countries. Pieri et al. (1995) proposed the land quality indicators to measure changes in the quality or condition of land and to promote land management practices that ensure productive and sustainable use of natural resources. Opschoor and Reijnders (1992) introduced sustainable development indicators to determine whether the development of a region or a nation is sustainable or not. In order to derive economical indicators that can give better guidance than the gross national product to those interested in promoting economic welfare, Daly and Cobb (1990) developed an index system of sustainable economic welfare.

For all these index systems, we designed a model for huge-indices decision making by means of differential geometry. This model applies to the situations that have more than 10 indices (indicators or criteria). The studied issues might sometimes required us to analyze, (1) the effects of negative factors, (2) the effects of positive factors, or (3) simultaneously both. In these three situations we must separately set up index system of negative factors or one of positive factors. For this index system, all indexes should be relatively independent.

Suppose that for an analyzed issue an index system has been set up as follows

$$(23) \quad z\left(1, j, t\right), \quad z\left(2, j, t\right), \quad ..., \quad z\left(i, j, t\right), \quad ..., \quad z\left(I, j, t\right)$$

For constructing a temporal dynamic model, a sub-period t would be temporarily fixed. Then, we can get the following algebraic matrixes

$$(24) \quad Z\left(t\right) = \left(z\left(i, j, t\right)\right)_{I \infty J}$$

Let

$$(25) \quad z_{max} = \max_{i, j, t} \left\{z\left(i, j, t\right)\right\}$$

$$(26) \quad y\left(i, j, t\right) = \frac{z\left(i, j, t\right)}{z_{max}}$$

$$(27) \quad y\left(0, j, t\right) = \frac{1}{I} \sum_{i=1}^{I} y\left(i, j, t\right)$$

$$(28) \quad \alpha\left(i, j, t\right) = y\left(i, j, t\right) - y\left(i-1, j, t\right)$$

$$(29) \quad k\left(i, j, t\right) = \left(\alpha\left(i, j, t\right) - \alpha\left(i-1, j, t\right)\right)\left(1 + \alpha^2\left(i, j, t\right)\right)^{\frac{3}{2}}$$

$$(30) \quad \alpha\left(0, j, t\right) = \frac{1}{I} \sum_{i=1}^{I} \alpha\left(i, j, t\right)$$

$$(31) \quad k\left(0, j, t\right) = \frac{1}{I} \sum_{i=1}^{I} k\left(i, j, t\right)$$

For the index system (23), the determination of the index weights is very important for constructing its model. Each set of weights would correspond to one kind of structure in the index system. Change of index weights would mean the model's structural dynamics. Different sets of weights would produce different results (or scenarios). The determination of the weights of the indexes have various ways such as choosing equal weights for all indexes, determining the weights by analysis of administrative levels or by a subordinate function of fuzzy sets. The weight system can be generally formulated as:

$$(32) \quad w\left(1\right), \quad w\left(2\right), \quad ..., \quad w\left(i\right), \quad ..., \quad w\left(I\right)$$

Where $i=1, 2, ..., I; j=1, 2, ..., J; t=1, 2, ..., T$;

$\sum_{i=1}^{I} w\left(i\right) = 1$; I is the total number of the indexes; j is the total number of analyzed regions; and T is the total number of analyzed sub-periods.

The common model both for negative factors and for positive factors in the jth region can be expressed as:

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$$(33) \quad CD(j,t) = sign(y) \cdot$$

$$\frac{1}{I} \sum_{i=1}^{I} w(i) \cdot \left(\begin{pmatrix} a^2(i,j,t) + \\ k^2(i,j,t) \\ + y^2(0,j,t) \end{pmatrix} \left(1 + a^2(i,j,t)\right)^{\frac{1}{2}} \right)$$

where

$$(34) \quad sign(\mathrm{y}) = \begin{cases} -1 & y\langle 0 \\ 1 & y\rangle 0 \end{cases}$$

The general model in the whole area investigated can be formulated as

$$(35) \quad GSCD(t) = \sum_{j=1}^{J} P(j,t) \cdot CD(j,t)$$

Where $P(j,t)$ is a parameter determined by the jth country or region; $CD(j,t)$ is the pattern in the jth country or region; $GSCD(t)$ is the general pattern in the whole analyzed area.

In order to know the leading indices in which countries or regions exist, we introduce two leading matrixes

$$(36) \quad M_{max}(t) = \left(M(i,j,t)\right)_{I \infty J}$$

$$(37) \quad m_{min}(t) = \left(m(i,j,t)\right)_{I \times J}$$

where

$$(38) \quad M(i,j,t) = \begin{cases} z(i,j,t) & z(i,j,t) \geq C_1 \\ 0 & z(i,j,t)\langle C_1 \end{cases}$$

$$(39) \quad m(i,j,t) = \begin{cases} 0 & z(i,j,t)\rangle C_2 \\ z(i,j,t) & z(i,j,t)\langle C_2 \end{cases}$$

$C_1 > C_2$; C_1 is the critical upper-value of the index system and C_2 is the critical lower-value of the index system.

According to concrete contents of some studied issues, dynamic characteristics of sector, ($y(0,j,t), a(i,j,t), k(i,j,t)$) are sometimes useful for bring to light the law of the discussed issues.

5. Discussions

The models in the approach of differential geometry to data mining have a common shell and need at most to deal with three variables, which are the curvature, the slope and the initial value, independently of the amount of data that are mined or the number of indices that must be handled. It is not necessary for the approach of differential geometry to construct a large number of models in order to process an enormous amount of data. The effective application of the approach of differential geometry to data mining requires performing four important steps. They include identifying the overall purpose of data mining, preparing data, operating model and evaluating results of the model. Because different purposes require very different data or index system, the overall purpose must be clearly stated in order to make the best use of data mining.

The step of preparing data is the most time consuming. It is quite possible that some of the data required has never been collected so that it may be necessary to supplement additional data. Because good models must be supported by good data, it is essential to assess data characteristics and to repair data defects. When data come from multiple sources, they must be consolidated into a single database. It is also important to ensure the same characteristics are measured in the same way. Once the data are gathered for the model to be constructed, it is essential to select specific data. When specific data are selected, some additional data transformations may be necessary. For instance, the operation of the model for huge-data in single-attribute-phase may require that the data be sorted out and correspondingly given plus or minus signs in relation to their contribution to the overall purpose. The operation of the model for huge-indices in multi-attribute-phase may require that the data be clustered and transformed into an index system according to certain algorithms.

After a model is constructed by means of the approach of the differential geometry, its results must be evaluated and their significance must be interpreted. When the model has been used, it must be measured how well it represented that data set. When the model performs well, the performance of the model must be continually monitored because all systems may evolve and data may change over time (Edelstein, 1998).

References

Carbone, P. L. 1998. Data mining: knowledge discovery in data bases. In: B. Thuraisingham (ed), Data Management, pp.611-624. Washington, D. C.: CRC Press LLC.

Daly, H. E. and Cobb, J. J. B. 1990. For the Common Good - Redirecting the economy towards community, the environment, and a sustainable future. London: Green Print.

Edelstein, H. 1998. Data mining—let's get practical. DB2 Magazine. http://www.db2mag.com /98smEdel.htm.

Haber, W. and Engelfried, J. 1997. Von Ökobilanzen zur Umweltverträglichkeit menschlicher Aktivitäten. Zeitschrift für Angewandte Umweltforschung, 10: 222-229.

Opschoor, H. and Reijnders, L. 1992. Towards sustainable development indicators. In: O. Kuik and H. Verbruggen (eds), In Search of Indicators of Sustainable Development, pp.7-28. Dordrecht: Kluwer Academic Publishers.

Organization for Economic Co-operation and Development. 1997. Environmental Indicators for Agriculture. 75775 Paris Cedex 16, France: OECD Publications.

Pfeiffer, K., Papcek, E. and Smith, D. 1998. What is data mining? http://www-personal.umd.umich.edu/~kpfeiff/index.html

Pieri, C., Dumanski, J., Hamblin, A. and Young, A. 1995. Land Quality Indicators. World Bank Discussion Papers, No. 315.

Small, R. D. and Edelstein, H. A. 1998. Scalable data mining. In: B. Thuraisingham (ed), Data Management, pp.637-647. Washington, D. C.: CRC

Spivak, M. 1979. A Comprehensive Introduction to Differential Geometry. Houston, Texas: Publish or Perish, INC.

Taylor, A. E. 1958. Introduction to Functional Analysis. New York: John Wiley & Sons, Inc.

The World Bank. 1996. Social Indicators of Development. Baltimore and London: The Johns Hopkins University Press.

Thuraisingham, B. 1997. Data Management Systems. Florida: CRC Press LLC. pp.173-185.

Yue, T. X., Haber, W., Grossmann, W. D. and Kasperidus, H. D.1999. A method for strategic management of land. In: Y. A. Pykh, D. E. Hyatt & R. J.M.B. Lenz(eds), Environmental Indices: Systems Analysis Approaches, pp.181-201. London: EOLSS Publishers Co Ltd.

Yue, T. X. 1994. Systems Models for Land management and Real Estate Evaluation. Beijing: China Society Press (in Chinese). pp.149-152.

Yue, T. X. and Ai, N. S. 1990. A morphological mathematical model for cirques. Glaciology and Cryopedology, 12(3): 227-234 (in Chinese).

Notes from the 1999 meeting of the North American Chapter of ISEM

The 1999 annual meeting of the North American chapter took place in Spokane, Washington, USA, 7-12 August 1999, in conjunction with the Ecological Society of America. Activities organized or sponsored by the chapter included one workshop, one symposium, one poster session and six oral sessions. The workshop, which was organized by Michael S. Corson, Bernard C. Pattern and Ellen K. Pedersen consisted of an introduction to systems analysis and simulation in ecology and natural resource management. Eleven people attended the two-day workshop. The symposium, organized by William S. Currie, included presentations that highlighted recent achievements and identified future directions on modelling nitrogen turnover in soils and availability to forest trees. All the poster and oral presentations covered diverse subjects: population dy-namics and wildlife management, landscape dynamics, carbon cycle of forest ecosystems and grasslands, natural resource management and risk assessment, forest succession, radionuclides transport, effect of toxic pollutants, remote sensing and geographical information systems. The abstracts for all the presentations and posters are included in this issue.

I left Spokane with an extremely positive impression of the meeting. All the presenters made high-quality presentations. ISEM meetings are excellent opportunities to learn about new developments, maintain contact with colleagues and evaluate the increasing importance of ecological modelling in various ecological fields. For instance, an excellent example of the increasing use of ecological modelling as aid-decision tools was provided by Thomas L. Barnwell in his presentation. I strongly recommend that you download the relevant EPA document and see by yourself (http://www.epa.gov/ORD/WebPubs/final/eco.pdf).

The first business meeting of the North American chapter following the re-organization of ISEM took place in Spokane. Mary Melin, publishing editor at Elsevier and ISEM liaison officer, made a presentation on the business partnership between ISEM and Elsevier and described the special benefits for ISEM members. There will be discounts as high as 35% for selected titles and for internet access to the virtual environment recently developped by Elsevier (http://www.virtual-enviornment. com) and to Ecological Modelling.

Y2K meeting will be an international meeting, as all the chapters will meet together in Halifax, Canada, under EcoSummit 2000. More information is provided at the following web site: http://www.elsevier.com/locate/ecosummit.

Guy R. Larocque
Natural Resources Canada
Canadian Forest Service

Abstracts of oral presentations and posters

ACEVEDO*[1,2], M.F., M. ABLA[2], S. PARMATI[1], D.L. URBAN[3] and A. MIKLER[1]. University of North Texas, Denton, TX, 76203, USA[1], Universidad de Los Andes, Merida VENEZUELA[2], and Duke University, Durham, NC, 27708, USA[3]. Parameterization of a landscape semi-Markov metamodel.
Contact e-mail: acevedo@unt.edu.

We discuss a method to parameterize a transition forest landscape model (MOSAIC) from a gap type model (FACET). This scaling-up method bridges the breach between scales in forest models. MOSAIC becomes a model of the FACET model, i.e. a metamodel. MOSAIC is semi-Markov and includes distributed and fixed delays in addition to transition probabilities. For each terrain class, the parameterization algorithm (SEMAPAR) operates on gap model output generated by code written to extract the proportion of gap model plots dominated by each landscape cover type. SEMAPAR monitors the transitions to estimate transition probabilities and probability density functions, assumed to be Erlang distributions with parameter values determined by nonlinear optimization. This process is repeated for each terrain class in the landscape. The number of terrain classes is selected to reflect landscape heterogeneity. As an example, we show the results obtained for 72 terrain classes (6 elevation intervals, 3 slope intervals and 4 slope aspects) in the H.J. Andrews coniferous forest in the Pacific Northwest of the USA. Computation time is reduced to approximately 6 hours by running FACET and SEMAPAR using a distributed queue mode in a set of several hosts via the network, and to approximately 1 hour by running it in a 16-node PC cluster.

BANCROFT, J. S., University of Connecticut, U-43 Storrs, CT, 06269, USA. Using statistical moments to fit hypotheses for the mechanism of dynamics in a fragmented population.
Contact e-mail: jsb95003@uconnvm.uconn.edu.

The mechanisms of density dependent regulation are significant for understanding population dynamics when the organism is resource limited. An individual-based simulation was created based on an experimental system of the sawtooth grain beetle kept in vials of flour. Data from the literature, specific experiments, and time series trials were used to calibrate 25 parameters of the model. Four more parameters were used to describe hypotheses of regulatory mechanism. Two parameters describe oviposition and two describe cannibalism as a function of density. Time-series data for egg, larvae, pupae, and adults were divided. The first part was used to determine statistical moments of the data and was used to fit the parameters (mean, variance, skew, kurtosis, autocorrelation). The held out data fell within the prediction interval of the fitted model. Data from a different times-series experimental was used for cross validation. This data exposed the sensitivity of the model to initial conditions. Similarly, by using the CI for the fitted parameters, the ability to predict long term dynamics is extremely difficult for these small populations.

BARNWELL*[1], T. O. and B. M. LEVINSON[2], National Exposure Research Laboratory, US EPA, 960 College Station Road, Athens, GA, 30605, USA[1], and National Center for Environmental Research and Quality Assurance, US EPA (8723r), 401 M St SW, Washington, DC, 20460, USA[2]. US Environmental Protection Agency's research strategy for ecological modeling.
Contact e-mail: Barnwell.Thomas@EPA.GOV.

EPA's Office of Research and Development (ORD) has released a research strategy to guide its program in ecosystem risk assessment and risk management (www.epa.gov/ORD/WebPubs/final/eco.pdf). The general direction of this research program is to larger scales, a more holistic systems view, assessment of cumulative stress, determination of relative vulnerability to multiple stressors, and development of alternative management strategies for flexible decision-making. To support this direction, we must develop the models to understand, predict, and assess the current and probable future exposure and response of ecosystems to multiple stressors at multiple scales and these models must be linked to landscape models to characterize future environments and habitats. In addition, ties to appropriate suites of biological response models are essential to the risk manager, because often the goal is to forecast the response of receptors to management actions, and models of socioeconomic change must also be integrated to assess future environments. Obviously, this is not a goal that can be accomplished by ORD alone, but will be dependent on contributions from in-house and extramural research programs, other agencies, the academic community, and others. The purpose of this paper is to provide an overview of ORD?s ecological modeling research program and discuss how the extramural community can contribute to its success through the Science to Achieve Results (STAR) extramural research programs in Regional Scaling, Water and Watersheds Research and Integrated Assessments.

CHEN*, X., L.T. WILSON and R.D. WEEKS. Texas A&M University, College Station, TX, 77843-2475, USA. An optimization model of the territory size of imported fire ants.
Contact e-mail: xchen@aesrg.tamu.edu.

An analytical model was developed and analyzed to investigate the variation and optimal size of territories of imported fire ants. The model considers the following constrains: the maximum radial distance than can be traveled by foraging workers, availability of food resource and foraging economy, size of ant colony and food demand, costs and benefits related to defending territory against neighboring colonies. The model predicts that the number of workers per unit area is greater in smaller territories than in larger territories.

COLBERT*, J. J., and G. RACIN. USDA-Forest Service, Northeastern Research Station, Morgantown, WV, 26505-3101, USA. Using a Java Applet to provide Web-based access to and data management for a forest gap simulation model.
Contact e-mail: jim@mserv.fsl.wvu.edu.

A Java Applet can be accessed through modern web browsers and used to reach server based simulation software and to store, retrieve, and edit data from a database. The Stand-Damage Model is a forest ecosystem gap simulator for tree growth with a Java interface and a user database. This system will provide for data entry from summaries by diameter and species on a per acre or hectare basis or directly from a field plot system of any design. If a user chooses to enter data directly from fixed area or variable radius prism plots (or both), the software will summarize all data and provide stand tables, stocking tables and other summaries prior to running simulations. Simulation scenarios can be designed and executed that include prescribed future management alternatives and defoliation episodes. There are three distinct ways to formulate management prescriptions. Output in graphical and tabular formats can be viewed, printed, stored, and retrieved. The system currently has full parameter sets for 67 tree species and means for a user to add up to 10 additional species, using on line documentation that defines all needed parameters and assists in setting parameter values by providing directions to on-line literature, a climatic range map for accumulated annual day-degrees in North America, methods for calculating growth rate parameters from diameter increment data, and other reference material in on-line documentation.

CORSON*, M.S., P.D. TEEL, and W.E. GRANT. Texas A&M University, College Station, TX, 77843, USA. Modeling detection of cattle-fever-tick infestations in semi-arid thornshrublands of south Texas.
Contact e-mail: m-corson@tamu.edu

Government programs maintain an 800-km quarantine zone along the Texas-Mexico border, within which inspectors regularly inspect cattle for evidence of cattle-fever-tick (*Boophilus annulatus*, *B. microplus*) infestations having slipped into the United States. We wished to examine the influence that variations in environment and management strategy have on the probability of detecting these infestations. We adapted a simulation model of Teel et al. (1998) that examines interactions of ticks, cattle, and landscape under a rotational grazing-system developed for semi-arid shrublands of south Texas. We added a submodel that estimates probability of inspectors detecting *Boophilus* infestations when examining 1, 20, 40, or 80 infested cows. Results suggest that detection probability was most severely influenced by the season in which the infestation began, followed by grazing strategy, habitat type, and number of cows inspected, and only moderately influenced by density of ticks in the initial infestation. Results showed high ($>=0.95$) detection probabilities exist as temporal "windows of opportunity" during brief but definite periods; outside these windows, detection of existing infestations becomes poor. Each halving of the number of cows examined tended to shorten duration of these windows by approximately 40%. However, probability of detecting tick infestations depends strongly on inspector training, cow behavior, and weather, which we considered implicit constants. Models such as this one may help predict timing and magnitude of *Boophilus* infestations, as well as favorable inspection periods.

CURRIE*, W. S. University of Maryland Center for Environmental Science, Frostburg, MD, 21532, USA. The problem of coupling C and N cycles to model soil N turnover in temperate forest soils.
Contact e-mail: currie@al.umces.edu.

A biogeochemical process model simulating redistributions of ^{15}N tracers in forest soil and vegetation pools has been developed and applied to gain insight into forest responses to manipulations at the Harvard Forest, MA, USA. The model is known as TRACE (Tracer Redistribution Among Compartments in Ecosystems), capable of modeling coupled, balanced, ecosystem-level fluxes of C, water, and N (as NH_4, NO_3, and organic N). Direct comparisons were made between model predictions and field data for recoveries of ^{15}N tracers in soil and vegetation. Comparisons among alternative model formulations showed that strong soil-detrital sinks for both $^{15}NO_3$ and $^{15}NH_4$ were required in order to account for observed ^{15}N redistributions. The model contains a balanced C budget within each soil horizon and at the ecosystem level (including DOC, dissolved organic C). Under traditional views of microbial C and N consumption, not enough C was available in soils to drive the necessary rates of gross N turnover in the model, making it necessary to decouple soil C and N turnover in order to account for observed ^{15}N sinks in soil. This raises a key question of how future models will be constructed to couple C and N cycling in forest ecosystems.

DAVIDSON*, E. A. The Woods Hole Research Center, Woods Hole, MA, 02543, USA. Are gross rates of N mineralization and nitrification needed for the hole-in-the-pipe model?
Contact e-mail: edavidson@whrc.org.

The hole-in-the-pipe model relates production of nitric oxide and nitrous oxide gas in soil to a metaphor of N flowing like a liquid through a pipe. The greater the flow of N through the pipe, which is analogous to the rate of N cycling through the ecosystem, the higher are the predicted emissions of gaseous N oxides that leak out holes in the pipe. Gross rates of N mineralization and nitrification are direct measures of N flowing through the pipe, but several indices of N cycling, such inorganic-N pool sizes, assays of net N mineralization, net nitrification, and nitrification potential, and litterfall-N, appear to work just as well for predicting N oxide emissions. The same may be true for predicting N availability to plants. A theoretical basis for this phenomenon will be explored. Understanding gross rates may be necessary to explain mechanistic relationships between N cycling indices and ecosystem functions, such as N availability to microorganisms and plants, but simpler empirical functions may be adequate and appropriate for many models.

DECURTIS, C.* and R. WIEGERT. Dept of Marine Sciences, University of Georgia, Athens, GA, USA. Theoretical behaviors of ecosystems developed and explained using simple mechanistic simulation models.
Contact e-mail: chuck@wiegert.marsci.uga.edu.

Consequences of differing theoretical postulates about ecosystem dynamics can be examined with simple models using flows of conserved units such as energy or an element. We use compartmental mechanistic models with ecologically realistic control functions separating, in particular, the effects of exploitative competition from those of intra- and interspecific interference competition. We examine the effects of changing trophic structure, changing biotic potential of trophic levels, degree of closure (nutrient recycling), and time delays. Many of the effects we illustrate have been observed in ecosystems and their models, or have been the subject of debate as to their presence in real systems. Here we present some plausible scenarios and their underlying mechanistic causes, providing a basis for discussion of the conditions under which the behavior would be found in nature and whether it might be common or rare. For example, stable limit cycles will arise in deterministic models with no significant time delays only with respect to certain combinations of: 1) the growth rate of a 'top consumer' relative to its limiting food resource(s); 2) the tolerance of the 'top consumer' to intraspecific interference competition; and 3) the availability of the food resource(s).

DIXON, K. R.*, S. R. ANDERSON, J. F. FAGAN, D. B. HOGAN, T. HUANG, C. F. MARTIN, J.C. ROBERTS, K. T. RUMMEL and L. L. SHEELER-GORDON. Texas Tech University/ Texas Tech Medical Center, Lubbock, TX, 79416, USA. An individual-based model for predicting population effects from exposure to environmental contaminants.
Contact e-mail: kdixon@ttu.edu.

A mathematical model (IBMOD) was developed to link exposure to environmental contaminants with population effects as reflected in reproduction and survival. IBMOD is a simple individual-based population model that uses probabilities for fecundity and survival on each individual in separate age classes. The model is stochastic, with reproduction, survival of each age class, number of males and females in the age class, sex ratio, offspring survival, and contaminant exposure as random variables. The model calculates the population size by summing the number of individuals in all age classes. The model was used to simulate the effects of pesticide ingestion on the populations of avian species with different feeding habits in and around agricultural fields in midwestern corn agroecosystems. For each species, Monte Carlo simulations of 100 individuals were run to obtain a population mean and 95 percent confidence interval of dose. Each simulation also predicted reproduction and mortality for each dose trace. Mortality was subtracted from the population of 100 individuals to estimate probability of survival. This model yields output comparable to an aggregated population model such as a Leslie Matrix model. The model predicted zero mortality for most species even with the conservative assumptions included in the model. Comparing the peak doses with the species' LD50 values suggests that the dose is not great enough to cause mortality in these species. The model simulations and post-simulation analysis predict no mortality will occur in the tested species from insecticide applications. Given the conservative assumptions used in the model, it is unlikely that significant and widespread mortality in avian populations in midwestern corn agroecosystems will occur from normal insecticide use.

DREISBACH*, T. A. and J.E. SMITH. USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR, 97331, USA. Predicting occurrence of chanterelles: habitat factors regulating distribution in the Pacific Northwest.
Contact e-mail: dreisbacht@fsl.orst.edu.

Fungi are important components of forest ecosystems, providing pathways for nutrient cycling and energy flow through food chains and webs; yet few tools exist for systematic evaluation of conditions that contribute to species occurrence, abundance, and viability. We are developing habitat models to predict occurrences for eight species of cantharelloid fungi (chanterelles) representing different life strategies ranging from rare to weedy. Our objective is to identify explanatory ecological factors significant to chanterelle distribution in the Pacific Northwest. Because few published studies have focused on fungus-habitat relationships, we employ exploratory data

analysis of unpublished data, historical records, and expert opinion to develop parameter estimations.Macrohabitat level landscape-scale features (elevation, vegetation composition and condition, canopy cover) correlate with species distribution and can be mapped to provide course estimates of suitable habitat. At the microhabitat level patchy distribution of fungal individuals indicates that features of the local environment such as relationship to coarse woody debris, fine-scale topography and moisture and moss cover are important factors related to fungal occurrence. Our analysis suggests that predicting fungal habitat necessitates a two-tiered spatial scale modeling approach, employing GIS and rules-based techniques.

FERREYRA[1], R. A, J. DARDANELLI[2], D.COLLINO[3] and L.B. PACHEPSKY*[4,5]. CEPROCOR and UNC, Cordoba, ARGENTINA[1], E.E.A. INTA Manfredi, ARGENTINA[2], IFFIVE INTA, Cordoba, ARGENTINA[3], RSML, USDA, Beltsville, MD, USA[4], and Duke University Phytotron, NC, USA[5]. Water stress related anomalies in the crop simulation model PNUTGRO: explanation using a leaf gas exchange model and thermodynamic analysis.
Contact e-mail: lpachepsky@asrr.arsusda.gov

PNUTGRO and other simulation models of the DSSAT family implement a linear relationship between water stress (expressed as a water supply/demand ratio) and photosynthesis. However, observations of dry matter production for peanut (*Arachis hypogaea* L.) crops in Cordoba, Argentina, matched PNUTGRO simulations in well-irrigated cases but were consistently higher than the simulations in cases with water-stress. The 2DLEAF model of leaf gas exchange was used to explain this observed nonlinearity. It showed that transpiration is very sensitive to stomatal aperture, whereas photosynthesis is not. However, consideration of the effect of reduced transpiration on leaf temperature is necessary. If transpiration decreases due to lower water availability, leaf temperature rises, enzymes may work outside their optimum temperature range and, consequently, photosynthesis may be reduced.To introduce this effect into the 2DLEAF simulations, an iterative optimization process is proposed, using a simple energy-balance model to estimate leaf temperature and photosynthesis as a function of stomatal aperture, air temperature, leaf dimensions, reflectivity, transmissivity, and emissivity, incident radiation, and estimated boundary layer parameters. The results are consistent with the leaf temperatures and dry matter production observed in the field experiments.

FLUG*, M., S. CAMPBELL, and J. BARTHOLOW. USGS, Midcontinent Ecological Science Center, Fort Collins, CO, 80525-3400, USA. Using a Systems Impact Assessment Model on a western river ecosystem.
Contact e-mail: marshall_flug@usgs.gov.

A modeling package was developed to evaluate changes in ecosystem health parameters on western rivers. This work supports a 1986 Act by the US Congress to restore anadromous fisheries to optimum levels by the year 2006 in the Klamath River Basin of Oregon and California. The US Geological Survey (USGS) worked with several agencies and local river partners to develop a better scientific understanding of the water quantity and quality problems limiting anadromous fisheries restoration. The USGS has integrated several stand alone models into a System Impact Assessment Model (SIAM) for resource management on the Klamath River. SIAM consists of computer models describing water flow, water quality, fish habitat quantity and quality, anadromous fish populations, and economics. This paper describes the use of SIAM to evaluate several water management alternatives (System Operating Flexibilities) for their potential to improve anadromous fish restoration. Particular emphasis is placed on water quantity, maximum and minimum reservoir storage levels, and water quality (temperature and DO) as measures of ecosystem health.

GRAY, D. R. Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre, Sainte-Foy, Québec G1V 4C7. The role of spatially structured environmental variables in outbreak patterns of the forest insect *Choristoneura fumiferana* (spruce budworm).
Contact e-mail: dgray@cfl.forestry.ca.

Approximately 44% of the variability of outbreak patterns of the spruce budworm (described by timing, duration, severity and uniformity of severity) was explained by spatially structured environmental variables that included climate, soil conditions and forest climax state. An additional 14% of the variability was explained by non-spatial environmental variation and simple geographic position of the outbreak. As would be expected, statistically important environmental variables included the proportion of the site that was forested, and the presence of the preferred host (*Abies balsamea*). Among the lesser expected environmental variables of importance were the presence of non-host species in the understory. The importance of these variables may derive from their effect on populations of natural enemies of the spruce budworm.

HERENDEEN*, R. A. Illinois Natural History Survey and University of Illinois, Champaign, IL, 61820, USA. Dynamic trophic cascades for large perturbations.
Contact e-mail: herendee@uiuc.edu.

I have previously investigated analytically the stock changes in a perturbed food chain. The approach covered trophic cascade and bottom-up: top-down paradigms. Both press-type (step function) and sinusoidal perturbations were assumed. The results supported the common observation that trophic cascade effects disappear roughly two trophic levels below the perturbed one. However, the method required the assumption of small perturbations. Several recent experimental or field results have involved perturbations leading to putative trophic cascades with large response. In at least one case there is a ten-fold change in biomass, so that a small-change approach is not applicable. Here I apply the same method to large changes. While the most general case is analytically intractable and requires numerical simulation, the method can be applied to several reasonable assumptions about predator-prey functional relationships. A tentative finding is that while large response to large perturbations can be generated, some observed extreme changes for levels trophically distant from the perturbations are unlikely. One possible explanation is that the observed systems were not at a steady state. This is a standard problem in perturbation experiments of ecological systems.

HERNANDEZ-CARDENAS[1], G. and F. MORA*[2]. Departamento de Biologa, Universidad Autonoma Metropolitana-Iztapalapa, Mexico[1]; Center for Advanced Land Management Information Technologies, and University of Nebraska-Lincoln, Lincoln, NE, 68588, USA[2]. Modeling wildfire potential from vegetation and drought conditions in Mexico.
Contact e-mail: mora@tan.unl.edu.

The severity and unprecedented outbreak of wildfires in Mexico during 1998 has lead to assume that "El Niño" Southern Oscillation [ENSO] may have a direct effect on regional fire risk. A probabilistic fire potential model [FPM], based on the probability of fire occurrence due to vegetation and drought conditions has been developed to evaluate the temporal and spatial patterns of fire potential for the country. The proposed model is based on the amount of live fuel load material, determined by the relative greenness [RG]; and drought conditions determined by the standardized precipitation index [SPI]. The RG provided an indication of the quantity of live vegetation at a particular date, and SPI provided a measure of precipitation deficit at multiple time scales and reflect the impact of drought for moisture availability. Relative greenness was derived from multi-temporal NDVI-AVHRR imagery from 1982-1993 and the SPI was derived from station meteorological data and interpolated into spatial surfaces covering the whole country. The temporal and spatial patterns of FPM were evaluated from model results and mapped using GIS technology. Major land cover types were used to determine "typical" trends and those due to short-term inter-annual variability and ENSO scenarios. Significant departures from the modeled fire potential trends were observed for ENSO years (1982-1983, and 1997-1998) indicating that drought conditions associated with "El Niño" have a significant effect on wildfire potential at regional scales.

HOBBIE*, E. A. National Research Council, US EPA, Corvallis, OR, 97333, USA. Incorporating mycorrhizal fungi and isotopes into models of C and N dynamics.
Contact e-mail: hobbie@mail.cor.epa.gov.

Process-based models of C and N dynamics have proven useful in many areas, but perplexing issues still remain. For example, the role of mycorrhizal fungi in supplying N to vegetation and in giving trees access to organic forms of N has been a topic of sharp debate but relatively little data. As a result, modelers have largely ignored the issue of fungal interactions with plants. However, ^{15}N measurements indicate that mycorrhizal fungi have large effects on plant ^{15}N. Consequently, ^{15}N can be used as an indicator of plant-mycorrhizal interactions. Furthermore, correlations between foliar ^{15}N and %N at a variety of sites indicate that ^{15}N is related to plant partitioning of carbon below-ground, illustrating that C and N cycling in plant-mycorrhizal systems are closely linked. If models are to be compared to natural abundance measurements and not just tracer addition experiments, then isotopic fractionations accompanying fluxes must be incorporated. Models that include mycorrhizal fungi and isotopic fluxes of C and N could provide new insights into ecosystem functioning. I will discuss several models that explicitly incorporate mycorrhizal fungi to explain patterns of ^{15}N and ^{13}C in plants and soils across gradients of N availability, succession, and soil depth. I will then discuss a variety of laboratory, field, and modeling approaches to address the issue of organic N use by fungi and plants.

HOBBIE, S. E.*[1] and P. M. VITOUSEK[2]. [1]University of Minnesota, St. Paul, MN, 55108, USA, and [2]Stanford University, Stanford, CA, 94305, USA. Nitrogen limitation of decomposition in terrestrial ecosystems: evidence and complications.
Contact e-mail: shobbie@tc.umn.edu.

We present empirical evidence that challenges two assumptions that commonly underlie ecosystem models regarding the effects of nitrogen (N) on decomposition. First, most models assume that N limits rates of decomposition (i.e., tissue with higher correlations of N decompose more quickly). Our research in Hawaiian forests, as well as a review of a number of other studies, shows that direct N fertilization of decomposing litter does not consistently result in faster rates of decomposition. Thus, direct and indirect evidence of N limitation of decomposition are in conflict. Here we explore explanations for these inconsistencies as well as implications for ecosystem model structure. Second, our work and that of others suggests that N immobilization by decomposing litter is driven as much by N supply as by N demand. This suggests that decomposer carbon:N ratios are flexible and that N immobilization by decomposers is a potential mechanism of N retention in ecosystems. Future modeling efforts should explore the sensitivity of ecosystem models to these assumptions.

HOFFMANN*, M., W. KOEHLER. Justus-Liebig Universitaet, 35390 Giessen, GERMANY. Modelling the spread of transgenes by pollen and the likelihood of hybridization between populations of the genus *Beta*.
Contact e-mail: marcus.hoffmann@agrar.uni-giessen.de,

Risk assessment concerning the commercialization of transgenic plants is difficult due to the lack of long term observations of the behaviour of transgenes in natural systems. Models are tools to predict the risks before carrying out the large scale cultivation. Pollen flow is the major way for the spread of transgenes from cultivated sugar beet populations to wild relatives. Different models are applied to simulate the spread of pollen. Cellular automata model, Gaussian Plume model and 'single-particle' model are compared. Model parameters are estimated and model fit is evaluated by means of results of release experiments and weather data, e.g. wind parameters. Using the results a first attempt is made to apply the model for large scale situations. The existing wild beet populations to be endagered by hybridization in Germany are found mainly at the coast of Kiel and Lübeck Bay (Baltic Sea). The likelihood of gene flow will be calculated based on average weather conditions and possible distribution of transgenic *Beta* cultivation.

JIANG*, H. and J. APPS. Canadian Forest Service, Northern Forestry Centre, Edmonton, AB, T6H 3S5, CANADA. Modeling the NPP, NEP and NBP dynamics of boreal forest under fire disturbance regime.
Contact e-mail: hjiang@nrcan.gc.ca.

Boreal forests play an important role in the global carbon budget. Net Primary Production (NPP), Net Ecosystem Production (NEP), and Net Biome Production (NBP) are the fundamental indicators of the contribution that biological productivity makes to the carbon cycle. In central Canada, the boreal forests can be divided into three eco-climatic types: high boreal, mid boreal and low boreal forests. In all three types, wild fire is a primary disturbance agent. In this paper, site-specific estimates of NPP and NEP in the three types of boreal forest ecosystems in central Canada were simulated using the terrestrial ecosystem process-based model (CENTURY 4.0). Regional estimates of NBP for the boreal forest transect case study (BFTCS) region of Central Canada were estimated using CENTURY together with a geographic information system. The simulation results show that fire disturbance significantly influences NPP, NEP and NBP in boreal forests of central Canada. The influence of different fire regimes (return interval and fire intensity) on NPP, NEP and NBP was also examined. The simulated NPP and NEP for the three eco-climatic regions showed obvious differences in their response, thus demonstrating that NBP is the most appropriate basis for accounting of terrestrial carbon at a regional scale. Comparison of changes in NPP, NEP and NBP under different fire disturbance regimes provides important insights on the potential changes in carbon source-sink relationships in boreal forests under a changing climate.

KANG, DAESEOK and SEOK SOON PARK. Ewha University, Seoul, 120-750, South Korea. Emergy evaluation of a hydroelectric dam proposal in South Korea.
Contact e-mail: dskang@ppp.kornet21.net.

Large-scale hydroelectric dams have been constructed for electricity, water supply, and flood control in South Korea. Their contributions to the economy of South Korea have been evaluated only using conventional accounting methods. However, long-term effects of the dams on the surrounding environments are not easily accounted for in those conventional methods. Emergy evaluation methodology (a scientifically based measure of wealth with units of solar emjoules) was used to better understand the overall contributions of a proposed large-scale hydroelectric dam in South Korea. The evaluation yielded a low net yield ratio (1.6/1) for the proposed dam if sediments were not included, and yielded a ratio of 1.2/1 if the sediments were included. The net yield ratios were less than 5 in any case when expressed as fossil fuels that is a primary energy source to the Korean economy. The evaluation suggests that the net contribution of the proposed dam to the economy would be questionable when compared with conventional fossil fuel plants. The results show that emergy evaluation can provide a new perspective in evaluating benefits and costs of large-scale dam constructions in South Korea.

KING, A. W.*, T.L. ASHWOOD, B.L. JACKSON and Y.I. JAGER. Oak Ridge National Laboratory, Oak Ridge, TN, 37831, USA. Spatial error and uncertainty analysis of ecological models.
Contact e-mail: awk@ornl.gov.

Ecological models are increasingly spatially explicit, relying on spatially distributed and georeferenced data as model input. The spatial inputs to these models, commonly in the form of geographical information system (GIS) data layers, have varying degrees of uncertainty associated with them. This uncertainty needs to be propagated throughout the entire modeling and simulation process so that: (1) model results can be presented as a probability distribution of possible outcomes; and (2) the contribution of uncertainty in spatial data to overall model uncertainty can be quantified. We describe the implementation of a general approach to the incorporation of uncertainty in spatial data into simulations with spatially explicit ecological models. The approach uses geostatistics and Monte Carlo simulation to propagate uncertainties in GIS data layers through the entire modeling process. We illustrate the approach and techniques with a case study of landcover data, habitat modeling and spatially structured avian demographics at Fort Knox, Kentucky.

LAROCQUE, G. R. Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre, Sainte-Foy, Quebec, Canada. Modelling daily gross photosynthetic rate in a sugar maple (*Acer saccharum* Marsh.) stand with detailed coupled photosynthesis and light attenuation functions.
Contact e-mail: glarocque@cfl.forestry.ca.

A process-based model that couples detailed photosynthesis and light attenuation functions was developed for sugar maple (*Acer saccharum* Marsh.) stands in Eastern Quebec. The photosynthesis part of the model is based on Farquhar's model and includes equations that represent the effects of temperature and foliage nitrogen content at different sections of the canopy. The vertical variation in leaf biomass and area was described using the Weibull distribution function in order to simulate photosynthetic rate in different sections of the canopy by using a radiative transfer approach. Parameterization of the model involved the establishment of permanent field stations for the measurement of photosynthetic rate at different sections of the canopy and the hourly monitoring of meteorological variables. Temporary sample plots were also established for the derivation of basic allometric relationships. Sensitivity analysis indicated that the gross production rate of sugar maple is sensitive to variations in temperature, solar radiation and foliage nitrogen content variation within the canopy.

LUCKAI*[1], N.J., D.M. Morris[2], D. Duckert[2] and J.M. Metsaranta[1]. Lakehead University, Thunder Bay, ON P7B 5E1[1] and Ontario Ministry of Natural Resources, Lakehead University, Thunder Bay, ON P7B 5E1[2]. Using the CENTURY model to predict effects of intensive management on black spruce stand productivity.
Contact e-mail: nancy.luckai@lakeheadu.ca.

Black spruce (*Picea mariana*) is the most important commercial tree species in the boreal forest of Ontario. The long-term effects of intensive forest management practices, such as shorter rotations and/or whole-tree harvesting, on site productivity and ecosystem integrity are unclear. Much of the controversy concerns the depletion and replacement of nutrients, primarily nitrogen, due to biomass removal and subsequent biotic and abiotic changes at the site. In this instance, the CENTURY model was calibrated for a moderately productive black spruce stand. Estimates of microbial biomass for surface and soil pools were also obtained and incorporated into the model. Output over an initial equilibrium period was validated by comparison to other reported datasets. Subsequently, 500-year simulations were run for full-tree vs. whole-tree harvesting and short (50 year) vs. long (100 years) rotation scenarios. Reductions in forest productivity were noted for both intensive practices. Model output indicated that nitrogen was not limiting. However nitrogen levels in soil pools declined. SOM pools also declined. Results suggest that "soft" forest management techniques appear to be best suited to the maintenance of site productivity in these forest ecosystems.

MCGUIRE*[1], A.D., J.S. CLEIN-CURLEY[1], J.M. MELILLO[2] and D.W. KICKLIGHTER[2]. University of Alaska Fairbanks, Fairbanks, AK, 99775, USA[1], and Marine Biological Laboratory, Woods Hole, MA, 02543, USA[2]. The sensitivity of simulated net ecosystem production in mature black spruce (*Picea mariana*) to two different formulations of soil nitrogen transformations in the Terrestrial Ecosystem Model.
Contact e-mail: ffadm@uaf.edu.

It is not clear whether modeling gross nitrogen mineralization in forest soils is necessary for simulating the carbon fluxes of forest ecosystems at large spatial scales. To evaluate this issue we compared the sensitivity of simulated carbon balance of black spruce (*Picea mariana*) to two different formulations of soil nitrogen transformations in the Terrestrial Ecosystem Model (TEM). One formulation represents net nitrogen mineralization (NMIN) as the difference between gross nitrogen mineralization and nitrogen immoblization and the other formulation represents NMIN as an aggregated flux that depends primarily on heterotrophic respiration. For parameterizations calibrated to black spruce ecosystems at the Bonanza Creek LTER, we compared simulations of carbon fluxes for an old black spruce ecosystem in northern Manitoba with eddy covariance measurements of carbon fluxes from the Boreal Ecosystem Atmosphere Study. Monthly carbon fluxes simulated between 1994 and 1997 with the two NMIN formulations are similarly correlated with tower-based estimates for monthly gross primary production ($r^2 > 0.9$), ecosystem respiration ($r^2 > 0.9$), and net ecosystem production ($0.7 > r^2 > 0.6$). In simulations from 1900 through 1994 across the range of boreal forest in North America, there was little difference in simulated carbon fluxes between versions of TEM based on the two NMIN formulations. Our results suggest that modeling gross nitrogen transformations in soils may not be necessary for simulating carbon fluxes in black spruce ecosystems at large spatial scales.

MAGNANI*[1], F., M. MENCUCCINI[2] and J. GRACE[2]. [1]Universita' della Basilicata,Italy, [2]University of Edinburgh, UK. Age-related decline in stand productivity: the role of structural acclimation under hydraulic constraints.
Contact e-mail: federico@imgpf.fi.cnr.it.

The decline in above-ground net primary productivity (P_a) that is usually observed in forest stands has been variously attributed to respiration, nutrient or hydraulic limitations. A novel model is proposed to explain the phenomenon and the co-occurring changes in the balance between foliage, conducting sapwood and fine roots. The model is based on the hypothesis that a functional homeostasis in water transport is maintained irrespective of age: hydraulic resistances through the plant must be finely tuned to transpiration rates so as to avoid extremely negative water potentials that could result in diffuse xylem embolism and foliage dieback, in agreement with experimental evidence. As the plant grows taller, allocation is predicted to shift from foliage to transport tissues, most notably to fine roots. Higher respiration and fine root turnover would result in the observed decline in P_a and growth efficiency. The predictions of the model have been compared with experimental data from a chronosequence of *Pinus sylvestris* stands. The observed reduction in P_a is conveniently explained by concurrent modifications in leaf area index and plant structure. Changes in allometry and shoot hydraulic conductance with age are successfully predicted by the principle of functional homeostasis.

MAILLY*[1], D., J.P. KIMMINS[2] and R.T. BUSING[3]. Ministry of Natural Resources, Sainte-Foy, QC, G1P 3W8, CANADA[1], University of British Columbia, Vancouver, BC, V6T 1Z4, CANADA [2], and USDA Forest Service, Corvallis, OR, 97331, USA[3]. Disturbance and succession in a coniferous forest of northwestern North America: simulations with Dryades, a spatial gap model.
Contact e-mail: daniel.mailly@mrn.gouv.qc.ca.

In this paper we describe a model of forest development that has been adapted for use in a coniferous forest of northwestern North America. The simulator, Dryades, is a spatial gap model used to examine the effects of disturbances of different types, sizes, and frequencies in mature Douglas-fir dominated forests on zonal sites of the Coastal Western Hemlock drier maritime (CWHdm) subzone of British Columbia. Simulation exercises were carried out to test the following (not mutually exclusive) hypotheses in relation to forest compositional variations observed within the study area today: (1) disturbance-mediated succession can accelerate the conversion of early successional forest communities dominated by pioneer tree species (e.g. Douglas-fir) to later successional associations; (2) when present in the canopy, long-lived, tall, pioneer species such as Douglas-fir strongly influence stand dynamics, regardless of the type of canopy disturbance; (3) silvicultural practices that emulate the autogenic natural disturbance regime of small canopy gaps will maintain a late-successional character at the stand level. Model simulations of forest successional dynamics suggested that: (1) repeated, small-scale disturbances such as light windstorms or small patch harvesting can accelerate the rate of tree species replacement by accelerating forest succession; (2) large-scale disturbances such as infrequent severe fires set back succession to an earlier seral stage dominated by Douglas-fir; (3) clearcutting without Douglas-fir planting accelerates forest succession towards a western hemlock/western redcedar forest; (4) on mesic sites in the CWHdm subzone, Douglas-fir will not dominate stand dynamics , unless there are infrequent, severe fire disturbances; (5) the creation of small openings through partial harvesting did not allow shade intolerant species to reestablish naturally and dominate the forest stand dynamics. It was concluded that modelled successional dynamics and composition of these forests are largely a function of the initial competitive interactions and the relative shade tolerance of species involved.

MATEJICEK*, L. Charles University, Benatska 2, Prague 2, 128 01, CZECH REPUBLIC. Spatio-Temporal Modeling in the GIS environment: dynamic processes of water pollution in streams.
Contact e-mail: lmatejic@mbox.cesnet.cz.

A few different levels of dynamic models of water pollution linked to the GIS environment are demonstrated. They range from simple spreadsheet's calculation and spatial visualization to building dynamic models as GIS extensions into complex standalone systems. The simplest case, spreadsheet's calculation, contains the user macros that solve dynamic models, support basic data visualization and produce outputs. The data output format can be processed and displayed with the GIS. The higher level, dynamic models as GIS extensions, can share the full functionality of the spatial information systems. The extensions for temporal modeling are in the form of internal programming modules. The complex systems are built with object-oriented programming tools that support relational database management, GIS functionality and numerical algorithms for simulation of dynamic systems.

Environmental models of dynamic processes of water pollution were used as examples. The transport of contaminants in the Rakovnik and Zelivka streams was modeled and compared with available data. The streams were divided into a number of parts. The amount of contaminants was predicted in each of them. The number of parts was estimated according to the stream morphology and the position of point and nonpoint source pollution. The simulation of models showed the mechanism of the pollution transport and examined various cases of spatio-temporal modeling systems

MORA*, F. and J.W. MERCHANT. University of Nebraska-Lincoln, Lincoln, NE 68588, USA. Modeling inter-annual changes in the onset of greenness with GIS.
Contact e-mail: mora@tan.unl.edu.

Satellite observations of vegetation growth and development show substantial interanual variation in timing of major phenological events. The principal objectives of this research are to (1) explain and (2) model variation in the timing of the "onset of greenness" (a metric that establishes the initiation of the growing season for different land cover types) over the conterminous U.S. It is assumed that vegetation growth is a functional response to the exchanges of energy, mass and momentum at the surface. Hence, the onset of greenness should be linked to variations in thermal units (i.e., growing degree days), evapotranspiration and other components of the energy and water balance that control major vegetation characteristics. Meteorological satellite imagery, climate data and discriminant analysis are used in a GIS-based model to predict onset of greenness for the years 1990-1993. It is shown that early dates of onset are usually associated with the thermal requirements of plant growth, while later onset dates are generally linked to water requirements. Growing degree-days and air temperature determine onset dates from February to March, but actual and potential evapotranspiration determine onset dates from April to July. Comparison of maps portraying the predicted (model-derived) and actual (based on satellite observations) dates of onset of greenness show close correspondence.

NORRIS*, K. S. and W. E. GRANT. Texas A&M University at Galveston, Galveston, TX, 77553-1675, USA. Results of a competitive, rank- and interaction-based population simulation model applied to group-living primates.
Contact e-mail: Oceanforest@Earthlink.Net.

The simulation model SOCIAL was developed to describe the effects of intergroup and intragroup competitive interactions on long-term population dynamics for group-living primates. Primates dependent on resources clumped in distribution tend to exhibit strong linear dominance hierarchies within groups. Competitive interactions determine access to limited food resources, with higher ranking groups and group members gaining priority access. Resource access affects fecundity and survival rates, thus affecting population structure and size. The SOCIAL model uses arrays to divide population members into ranks within age, sex and reproductive-state modules. Animals are divided between four groups, though they may migrate between groups. Using "interaction" submodels, the model explicitly defines the effects of status and competitive interaction outcomes on population dynamics. Fifty 100-year-long model simulations using SOCIAL were run under four different rainfall and habitat fragmentation patterns, and were compared with an identical model, NONSOCIAL, which ignored competitive interactions and rank-related differences. The models showed widely different outcomes under all scenarios. Mean, minimum, and maximum population size were lower for the SOCIAL model under all fragmentation and rainfall conditions (Student's t, $P < 0.01$ in all cases). Population size and adult sex ratio volatility rates were higher in the SOCIAL model (Student's t, $P < 0.01$ in both cases). The SOCIAL model showed greater sensitivity to changes in habitat fragmentation patterns than the NONSOCIAL model.

PACHEPSKY*[1,2], L. B., R. A. FERREYRA[3,4], L. LU[5], Zh. LU[1] and B. ACOCK[1]. RSML, ARS, USDA, Beltsville, MD, 20705, USA[1], Duke University Phytotron, Durham, NC, 27708, USA[2], CEPROCOR, Cordoba, ARGENTINA[3], Universidad Nacional de Cordoba, Cordoba, ARGENTINA[4], and CSL, ARS, USDA, Beltsville, MD 20705, USA[5]. Measuring tissue dimensions on leaf cross-sections using supervised image classification techniques.
Contact e-mail: lpachepsky@asrr.arsusda.gov.

A simple and fast image-analysis technique is presented for measuring the sizes of mesophyll, water storage, and epidermal cells, and the area of the intercellular space in leaf cross-sections of peanut (*Arachis hypogaea* L.), soybean (*Glycine max* L.), and Pima cotton (*Gossypium barbadese* L.). Cross-section microphotographs were digitized, and the resulting RGB color images were processed with image processing software to produce artificial "bands" by histogram equalization and color adjustment. All images were then imported into the GIS package Idrisi. The original image was processed with a maximum likelihood classifier using the processed images to develop signatures for the different tissues. The sizes of the tissues and the intercellular spaces were then measured using a pixel-counting function. The data obtained were similar to the results of conventional measurements with software packages like SigmaScan, where all the features must be completely digitized all across the image. The classification-based technique requires only about 10% of the image for classification training sites, and it takes about 80% less time than conventional measurements, with an error of less than 5%.

PARDO*, L. H. USDA Forest Service, Burlington, VT, 05402, USA. Natural abundance of ^{15}N as a tool for improving N cycling models.
Contact e-mail: lhpardo@athena.mit.edu.

Two important questions in modeling N cycling in forest ecosystems are how much N is available for plant uptake and what is the form of that N. Natural abundance of ^{15}N can give us insights into the workings of the nitrogen cycle and therefore be a useful tool in improving N cycling models. In this paper I give three examples of the information that this technique can provide. First, ^{15}N and ^{18}O in streamwater and precipitation can be used to evaluate the source of nitrate in streamwater. Results of a study in NH suggest that little nitrate moves through the ecosystem without microbial interaction. Second, changes in foliar ^{15}N following a clear-cut, demonstrate an uptake preference for ammonium versus nitrate, although, it is not possible to calculate an uptake preference ratio. Finally, disturbance-induced increases in ^{15}N were detectable for a longer period of time in the Oie horizon than the Oa horizon, even though turnover time is shorter in the Oie horizon. These results suggest that the horizons may need to be modeled separately. In summary, stable isotopes can integrate N cycling information over both time and space, and can be used to elucidate fundamental processes important for N cycling models.

PARK*[1], R. A., J. S. CLOUGH[1], H. GALBRAITH[2], R. JONES[2] and S. H. JULIUS[3]. Eco Modeling, Montgomery Village, MD, 20886, USA[1], Stratus Consulting Inc., Boulder, CO, 80306, USA[2], and U.S. Environmental Protection Agency, Washington, DC, 20460, USA[3]. Modeling impacts of sea-level rise on coastal habitats.
Contact e-mail: dickpark@erols.com.

The Sea Level Affecting Marshes Model (SLAMM), Version 4, uses coastal data that can be downloaded from the Internet to predict potential impacts of sea-level rise due to global warming. With USGS National Wetland Inventory and Digital Elevation Model data and NOAA tidal data we modeled wetland habitats with a resolution of 30 m. Differences in tidal ranges, regional and local subsidence, and land use are reflected in differences in vulnerability to sea- level rise in various coastal areas. According to the model, habitat loss will affect important fishery nursery grounds and flyways, especially on the Gulf Coast.

PARK*[1], R. A., J. S. CLOUGH[1], M. C. WELLMAN[2], D. A. MAURIELLO[2], and D. J. D'ANGELO[3]. Eco Modeling, Montgomery Village, MD, 20886, USA[1], U.S. Environmental Protection Agency, Washington, DC, 20460, USA[2], and Procter & Gamble Co., Cincinnati, OH, 45217, USA[3]. Modeling stress of conventional and potentially toxic pollutants on aquatic ecosystems.
Contact e-mail: dickpark@erols.com.

With the AQUATOX model we estimate the impacts of nutrients, temperature, sediments, and organic chemicals on aquatic ecosystems. Because two representative taxa from each major algal group and invertebrate and fish guild can be simulated, the vulnerability and resilience of a relatively complex food web can be analyzed. Ecosystem dynamics, chemodynamics, and chronic and acute toxicity are all modeled so that both direct and indirect effects of stressors can be considered. Validations have been performed for streams, lakes, reservoirs, and ponds.

PARK, SEOK SOON*[1], EUN JUNG KIM[2], and YONG SEOK LEE[3]. Ewha University, Seoul 120-750, South Korea[1], Korea Institute of Construction Technology[2], Hallym Information an Industry College[3]. Development and Application of a Water Quality Model for Large River System with Autochthonous Sources and Denitrification.
Contact e-mail: ssp@mm.ewha.ac.kr.

A water quality model, KQUAL97, was developed for large river systems where autochthonous sources and denitrification play an important role in BOD and nitrogen dynamics. The model was based on the USEPA's QUAL2E and several modifications were made in the computer code to overcome limitations of QUAL2E. These include the modification of computational structure and the addition of new constituent interactions, such as algal BOD, denitrification, and DO change caused by fixed plant. To validate the program modifications, both KQUAL97 and QUAL2E were applied to the same river with heavy growth of algae and the results were compared. The parameters to be tested include DO, BOD, nutrients, chlorophyll-a, and SS. KQUAL97 displayed better agreement with the field measurements in BOD and nitrogen than QUAL2E. After program validation, KQUAL97 was applied to the Nakdong river, one of the largest river systems in Korea. The river drains an area of 23,817 square kilometers and length of the main stem is over 500 kilometers. The model covered the main stem and nine major tributaries with 54 reaches and 9 junctions. After calibration and verification, the model was utilized for the waste load allocation anlysis. This study showed that the developed model was very useful to simulate the water qualities of large river systems with heavy algal growth.

PATTEN*[1], B.C., B. D. FATH[2] and J. S. CHOI[3]. Institute of Ecology, University of Georgia, Athens, GA, 30602, USA[1], School of Forest Resources, University of Georgia, Athens, GA, 30602, USA[2], and Department of Biological Sciences, University of Montreal, Montreal, Quebec, H3C 3J7, CANADA[3]. Network thermodynamics analysis: formulation and unification of several ecological goal functions.
Contact e-mail: bmpatten@earthlink.net.

This paper summarizes a set of network thermodynamic analyses of energy flow and storage in steady-state systems. Network analyses are used to identify and quantify first passage (non-cyclic), cycled, and dissipated modes of transfer. First-passage throughflow between source and terminal compartments, which is dependent on the strength of the energy gradient in which the system is embedded and its efficiency at capturing this energy, is always strictly equal to the amount of energy dissipated from terminal compartments. However, cycled energy at terminal compartments represents "added" throughflow which can pass between system components multiple times. Cycling is determined by within-system transfer efficiencies and system connectivity. The added throughflow makes it possible for open systems, when taken in reference to one another, to experience net aggradation (ordering) over and above the work performed and the heat dissipated. Therefore, cycling is the central property of biological and ecological systems which makes possible "negentropic" behavior. We use the network perspective to codify and unify several ecological goal functions: maximum power, maximum storage, maximum ascendency, minimum specific dissipation, maximum cycling, and maximum dissipation. When viewed within the aggradative framework, all these goal functions are mutually consistent.

PATTEN*[1], B. C. and R. W. SAGE[2]. University of Georgia, Athens, GA, 30602, USA[1], and SUNY Adirondack Ecological Center, Newcomb, NY, 12852, USA.[2]. The Adirondack whitetail as a process in an ecosystem: a linear dynamic model.
Contact e-mail: bmpatten@earthlink.net.

Two points are made in this paper: 1. Organisms in ecosystems are not the discrete objects they seem to be when taken in isolation; they are processes dependent upon and integrated within the fabric of the whole. 2. The organism-system integrated relationship can be modeled in realistic detail employing a long advocated but little practiced style of modeling which assigns linearity to the state space and nonlinearity to the parameter space. These ideas are illustrated by a STELLA-implemented life-cycle model of the whitetailed deer (*Odocoileus virginianus*) in the Adirondack Mountain ecosystem of New York.

PEDERSEN*[1], E. K., W. E. GRANT[1], J. W. CONNELLY[2], and J. HENDRICKSON[3]. Texas A&M University, College Station, TX, 77843-2258, USA[1], and Idaho Department of Fish and Game, Pocatello, ID, 83204, USA[2], and US Sheep Experiment Station, Dubois, ID, 83423, USA[3]. Multiple use of rangeland resources: simulation of sage grouse-sheep interactions in a sagebrush community in southeastern Idaho.
Contact e-mail: ellen@stat.tamu.edu.

A dynamic model was constructed to determine the effect of sheep management on declining populations of sage grouse (*Centrocercus urophasianus*) in the sagebrush (*Artemisia spp.*) rangelands of southeastern Idaho. The model consists of submodels representing (1) sage grouse population dynamics, (2) vegetation dynamics, including sagebrush, herbs, and forbs, and (3) livestock management, representing seasonal and habitat distribution of sheep grazing pressure. The model was developed and evaluated via a series of workshops involving livestock, rangelands, and sage grouse specialists from academic, governmental, and private organizations, as well as local ranchers. Preliminary sensitivity analysis indicates that grouse populations are most sensitive to mortality rates of 1- to 6-week-old chicks, while sagebrush dynamics are most sensitive to the frequency, size, and seasonality of fire. Initial simulations exploring alternative land use strategies suggest that grazing by sheep has relatively little impact on sage grouse populations at grazing intensities typical of sagebrush rangelands in southeastern Idaho. Changes in land use patterns that reduce quantity and quality of sage grouse nesting and brooding habitat have a relatively greater impact.

SIZONENKO*, V. P. Institute of Mathematical Machines and System Problems, Kiev, 252187, UKRAINE. Modelling with increased accuracy radionuclides transport in the Kiev reservoir.
Contact e-mail: sv@dem.ipmms.kiev.ua.

The article analyzes opportunities of the box model on complete mixing of the distribution ^{90}Sr in the Kiev reservoir after the Chernobyl accident and defines factors that influence mostly pollution transport. These types of models are less sensitive to the quality of initial data in comparison with existing, more complex, 1-, 2-, 3- dimensional models and require less computing time. The description of a new non-full mixed box model with a retarded parameter is presented. It gives the opportunity to describe the process with increased accuracy. As a result, the model UNDBE predicts with greater accuracy the concentration of a pollutant in the outflow of the reservoir, particularly in the case of a short time forecast. This approach does not require more detailed field measures than the full mixed camera model. The degree of complexity in the mathematical structure and computer code has not increased significantly. The block of parameter's identification has been included in the model software, which allows the selection of the best parameters of the model. Therefore, it becomes possible to increase model accuracy and to calibrate the model for concrete reservoir and pollutant, to use the model for various prognostic tasks and to solve optimization problems for water usage. The calculations and identification of parameters were made from field measurements during the 1994 spring flood resulting from ice jam.

TIETEMA*, A. and W. BOUTEN. University of Amsterdam, Nieuwe Prinsengracht 130, 1018 VZ Amsterdam, THE NETHERLANDS. Parameter identification in incubation experiments.
Contact e-mail: a.tietema@frw.uva.nl.

Sensitivity analyses of process-based models of biogeochemical transformations often reveal the same microbial parameters to which the models are most sensitive. These parameters are for instance the microbial carbon-use-efficiency and the microbial carbon-to-nitrogen ratio. A common characteristic of these parameters is that they are difficult or sometimes even impossible to measure directly in the studied system. This means that the values of these essential parameters can be quantified only by parameters optimalization by means of inverse modeling. However, a parameter optimalization in these incubation studies never yield a unique set of parameter values, which means that the outcome contains of many possible combinations of parameter values describing the results. This strongly limits the potential quantitative use of these experiments. In this presentation, we will discuss several solutions to quantify parameter values. They vary from increasing the information content of the measurements, analyzing the experimental results to determine what stage of the experiment contains the most information of the different parameters, to the optimal use of isotopes in incubation experiments. In addition, we will present an example of an incubation experiment based on the principles of the Substrate Induced Respiration method of determining microbial biomass to illustrate some of the solutions.

VALENTINE, H.T. USDA Forest Service, Northeastern Research Station, Durham, NH 03824. Modeling stand growth in a changing atmosphere.
Contact e-mail: hvalentine/ne_du@fs.fed.us.

Recent findings regarding the magnitude of the influence of carbon dioxide concentration on the rate of photosynthesis in loblolly pine have been incorporated into a model of carbon allocation and growth. The model translates photosynthetic rates into rates of change in stand basal area, quadratic mean diameter, tree density, average tree height, average crown length, dominant tree height, and woody dry matter. The model was used to project the growth of loblolly pine stands in Virginia under the assumption that the atmospheric concentration of carbon dioxide will continue to increase by 1.6 ppm/yr, the average rate of increase in the last ten years. In addition, mean annual temperature was assumed to warm by 0.02 K/yr. The projections suggest that, in 20 years, the amount of woody dry matter in 20 year-old stands will be, on the average, 8 to 10% greater than the amount of woody dry matter in 20 year-old stands today. Similar increases in yield should be expected throughout the range of loblolly pine. Consequently, many yield tables and models will be rendered inaccurate unless adjustments are made to account for changing atmospheric conditions.

WOHLFAHRT*[1,2] G., M. BAHN[2], U. TAPPEINER[3,2] and A. CERNUSCA[2]. Centro di Ecologia Alpina, Trento, TN, 38040, ITALY[1], University of Innsbruck, Innsbruck, 6020, AUSTRIA[2], Europsche Akademie Bozen, Bolzano, BZ, 39100, ITALY[3]. A model of whole plant gas exchange and its application to herbaceous plant species from differently managed mountain grassland ecosystems.
Contact e-mail: Georg.Wohlfahrt@uibk.ac.at.

Within the EU-project ECOMONT a model was developed which aims at quantifying the CO_2 and H_2O gas exchange of whole plants in their natural microenvironment, the canopy. In an up-scaling approach the model combines leaf (gas exchange, energy balance) and canopy (radiative transfer, wind attenuation) scale simulations. Net photosynthesis and stomatal conductance are modelled using a nitrogen sensitive model of leaf gas exchange. An analytical solution to the energy balance equation is adopted to calculate leaf temperatures. Radiative transfer, separately for the wavebands of photosynthetically active, near-infrared and long-wave radiation, is simulated by the means of a model which accounts for first order scattering of radiation, using detailed information on canopy structure as input data. The partial pressures of CO_2 and H_2O, as well as air temperatures within the canopy are not modelled, but measured values used as input data instead. Field studies were carried out at the ECOMONT pilot study area Monte Bondone (Trentino/Italy, 1550 m a.s.l.). The model is parameterised for four forbs and one graminoid species occurring at three sites differing in land use, i.e. an abandoned area, a meadow and a pasture. Independent measurements are used to validate each of the major sub-models of the comprehensive whole plant gas exchange model. Selected examples show how the model may be applied to assess effects of land-use changes on whole plant gas exchange of mountain grassland species.

YANG*[1], X. H., Q. GAO[2] and M. YU[1]. University of Connecticut, Storrs, CT, 06269, USA[1], and Chinese Academy of Sciences, Beijing, CHINA[2]. Scaling simulation models for spatially heterogeneous ecosystems.
Contact e-mail: xyang@canr1.cag.uconn.edu.

The dependence of simulation models on scales for spatially heterogeneous ecosystems was investigated. The dependence was found largely attributed to the nonlinearity of the model. Increasing scale or decreasing spatial resolution of a model tended to overestimate rate of ecosystem processes with diffusive spatial mass/energy transportation and Logistic competition. A technique for scaling a simulation model was developed by means of Taylor expansion of nonlinear functions of the spatial variables in the model. General scaling terms in this type of models were derived by running the model at finer scale resolution for selected grid cells in a coarser frame. The technique was applied to a grassland landscape in northeast China and the result was compared against five year observations on community succession. The results indicated that the present technique can effectively reduce overall scaling error of the model by as much as 50%, depending on the linear difference between the fine and the coarse resolutions as well as the sampling scheme used.

YUE*, T. X. State Key Laboratory of Resources and Environmental Information System, Datun, Anwai, 100101 Beijing, P. R. CHINA. A general model for handling ordered data in huge number and its application.
Contact e-mail: yue@lreis.ac.cn.

The technology of information collection and manipulation, which integrates Global Positioning System, Remote Sensing, and Geographical Information System, has made us have capacity to obtain highly dynamic data flow. If all information at every point on the Earth is put in order according to longitude, latitude and time, the ordered data in three dimensions can be reached. To effectively handle these ordered data in huge number, we construct a general model by means of differential geometry. The major contents of this general model include: (1) two of the variables (longitude, latitude and time) are temporarily fixed and the ordered data in huge number are transformed into a plane curve; for any plane curve, it is enough to analyze three parameters that are intercept, slope and curvature to find the characteristics of the ordered data; (2) in order to analyze the reasons that have caused the characteristics, matrixes of leading factors are included in the general model; (3) finally, the temporarily fixed variables are respectively allowed to change freely. In the case-study, spatial and temporal dynamics of land cover in China are studied by operating the general model on the vegetation index month by month from 1982 to 1992

WU*, J. Arizona State University West, Phoenix, AZ, 85069, USA. Hierarchical modeling: a scaling ladder approach.
Contact e-mail: jingle@asu.edu.

Hierarchy theory suggests that ecological systems are nearly decomposable systems, and such systems can thus be simplified based on the principle of time-space decomposition. Patch dynamics provides a powerful way of dealing explicitly with spatial heterogeneity, and has emerged as a unifying concept across different fields of earth sciences. In this presentation, I present a cross-scale modeling and scaling strategy based on the hierarchical patch dynamics framework. The strategy consists of three stages, each of which may involve a number of steps and methods: (1) identifying appropriate patch hierarchies, (2) making observations and developing models of patterns and processes around focal levels, and (3) extrapolation across the domains of scale using a hierarchy of models. Identifying and taking advantage of the hierarchical structure and near-decomposability of complex ecological systems are essential to understanding and prediction because a hierarchical approach can greatly facilitate simplification and scaling. I argue that patch hierarchies can be used as "scaling ladders", and this scaling ladder approach can help simplify the complexity of systems under study, enhance ecological understanding, and minimize the danger of intolerable error propagation in translating information across multiple scales.

Letter from the Editor

ECOMOD has a new Editorial Board. I would like to express my sincere thanks, both personally and on behalf of ISEM, to the previous Editorial Board: Ellen K. Pedersen (Editor-in-chief), Wolfgang Pittroff (Associate Editor) and P. Fred Dahm (Associate Editor). They did an excellent job during their two-year term and deserve our deepest consideration. Fortunately, Ellen has agreed to remain on the new Editorial Board as Associate Editor; we will certainly benefit from her previous experience. Besides myself, the other members of the Editorial Board include Miguel F. Acevedo, University of North Texas, TX, USA, Michael S. Corson, Texas A & M University, TX, USA, and Tian Xiang Yue, Chinese Academy of Sciences, China. I thank them for agreeing to serve as Associate Editors. The main duties of the Editorial Board are to bring new ideas to ECOMOD and ISEM, review articles and looking for contributions. Any other ISEM member who would like to join the board is more than welcome. As far as I am concerned, excellent ideas can emerge from a group of people with various fields of expertise. There is no immediate plan to modify substantially the format of ECOMOD. As before, there will be articles for the Perspectives sections, book reviews, notes from the officers and members, conference announcements, etc. If you have ideas or would like to see new features in ECOMOD, by all means, let us know by contacting a member of the Editorial Board.

Guy R. Larocque
Editor

Book Review

Review of Environmental Information Systems by O. Gunther, Springer, 244pp, 1998

This is a graduate level text and, as such, should do well. Its hypothesis is that the time is ripe to address the capture, storage and analysis of environmental data using modern computer technology. The material seems to be written at the appropriate level for graduates, with a sprinkling of examples. While these are somewhat biased in their selection, this is fine in a course text - the book does not pretend to offer a comprehensive literature review after all. Indeed, the author purposefully eschews topics such as GIS and simulation on the (correct) grounds that there are many other texts on these topics. These two issues are included only in passing to provide links to this other, more extensive literature.

After an introductory, scene-setting chapter, there are four main chapters. Chapter 2 describes issues of data capture using specific illustrations from water chemistry (the example here is the WANDA system with a focus on chromatographic data) and the use of satellite imagery.

Chapter 3 concentrates on data storage issues and discusses what a DBMS (database management system) can offer for environmental data. Spatial data and spatial query languages are discussed in detail as are various tree structures for multidimensional access. This is probably the most extensively described part of the book for which the student probably need some background in computing ideas (as well as concepts from probability needed in earlier chapters). Newer object-oriented techniques are described from the OO database viewpoint of behavioural and structural object-orientation: terminology not used outside this specialized subfield of object technology.

In the fourth chapter, the topic is data analysis and data support. Again, no complete coverage is attempted but the basic discussion will be found useful. Here a model for smog analysis is used as the case study. A section follows about GIS (despite the comment above) followed by an interesting catalogue of where to find further information on-line. The chapter concludes with a description of a real-life implementation in the city of Baden-W"urttemberg in Germany where an environmental information system (called UIS) has been used as a showcase project for how to manage the state's environmental activities.

The final chapter discusses metadata, that is, the data that describe the environmental data themselves. In the context of databases, the metadata are exempli-

fied by the database schemata. An example then follows in the US National Spatial Data Infrastructure (NSDI). The final section describes the UDK environmental data catalogue used in Austria and Germany. The reference list is extensive, pointing students to further reading, but incomplete in its coverage being biased to German sources.

Overall, this book provides a useful course text at the graduate level. It retains the students interest and challenges them to read around the subject without degenerating into a research monograph. Certainly worth your consideration.

Brian Henderson-Sellers
School of Computing Sciences
University of Technology, Sydney

Review of Integrated Approach to Environmental Data Management Systems edited by N.B. Harmancioglu, M.N. Alpaslan, S.D. Ozkul and V.P. Singh, NATO ASI Series 2: Environment - Vol 31, Kluwer Academic Publishers, Dordrecht, 546pp, 1997, US$227, #139

It is clearly the case that the integrated nature of the environment requires a holistic approach to data collection, analysis and management with respect to the various environmental elements that impact human societies. This was the focus of this NATO Advanced Research Workshop held in Turkey in 1996. It is perhaps surprising (and maybe even disappointing) that it is stated (page 434) that the main conclusions from the workshop ``basically constitute the initial step towards integration''. Indeed, the integration upon which these many delegates focussed, and as represented by their many papers in this edited volume, is most evident in this Conclusions and Recommendations chapter.

The bulk of the volume is what we have come to expect from conferences, including of course these NATO Workshops: relatively short research papers bearing no other than coincidental relationship to any other. Granted the editors have grouped these papers into related topics but, unlike a course text, no attempt is made (as is normal) to identify common threads between papers from research groups across the globe who have probably had no communication prior to meeting at this conference. It is thus very welcome to find an extensive summary chapter (Part IX) which draws together all these potentially disparate strands of interesting argument.

The overall structure of the book is in ten parts, seven of which have a subdisciplinary focus, preceded by an introduction and followed by the Summary and Conclusions section noted above and then a major section (approximately 100 pages) describing a range of interesting case studies.

The sections discuss (II) objectives of environmental data management, (III) design of data collection networks, (IV) sampling and data presentation, (V) data processing, (VI) statistical sampling and analysis, (VII) databases and (VIII) using data for decision making.

Overall, the book, while overpriced, is well produced and a good starting point for someone wishing to identify current research topics in this important area of environmental data collection, analysis, integration and use in decision making. The Workshop aimed to achieve a major output of a set of recommendations for promulgation to politicians, national and international environmental bodies and community members. This seems to have been successfully achieved.

Brian Henderson-Sellers
School of Computing Sciences
University of Technology, Sydney

Workshop announcement

The forthcoming Ecosystem Model-Data Intercomparison (EMDI) workshop will, for the first time ever, compare a wide array of global carbon cycle models with field measurements of terrestrial net primary productivity (NPP). An initial EMDI workshop to explore model/data comparisons will take place at the University of New Hampshire, Durham, NH, USA, 5-8 December 1999. EMDI will utilize synthesized data from the Global Primary Productivity Data Initiative (GPP-DI) working groups, which were held with support from the U.S. National Center for Ecological Analysis and Synthesis (NCEAS) and the International Geosphere-Biosphere Program Data and Information System (IGBP-DIS). Methods for synthesizing and extrapolating sparse field observations of above-ground and below-ground NPP were developed during these working groups to create consistent estimates of total (above + below-ground) NPP at individual site and regional-scale grid cells.

EMDI will expedite the state-of-the-art towards the developmont of global carbon cycle models, and is expected to greatly advance this important area of ecosystem science. A number of publications in international journals are expected to result from the overall EMDI process. Following the EMDI activity, datasets of observed data (e.g. NPP), and model-forcing data (e.g. climatologies, soils) that contribute to the EMDI activity will be publicly available for other ecological applications (biodiversity studies, nutrient cycling, etc.).

For additional information or details, contact:
Kathy Hibbard
IGBP/GAIM
Climate Change Research Center
University of New Hampshire
Durham, NH 03824, U.S.A.
Fax: +1 (603) 862-2124
Email: k.hibbard@unh.edu

Publication Information

EDITOR:
Guy R. Larocque
Natural Resources Canada
Canadian Forest Service
Laurentian Forestry Centre
1055, du P.E.P.S.
P.O. Box 3800
Sainte-Foy (Quebec)
G1V 4C7   Canada
Tel: 418-648-5791
Fax: 418-648-5849
E-mail: glarocque@cfl.forestry.ca

ASSOCIATE EDITORS:
Miguel F. Acevedo
Department of Geography
University of North Texas
Denton, TX 76203, USA
E-mail: acevedo@unt.edu

Michael S. Corson
Dept. of Wildlife and Fisheries Sciences
Texas A&M University
College Station, TX, 77843-2258 USA
E-mail: m-corson@tamu.edu

Tian Xiang Yue
State Key Laboratory of Resources and
Environmental Information System
Chinese Academy of Sciences
917 Building, Datun, Anwai
100101 Beijing, P.R. China
E-mail: yue@www.Ireis.ac.cn

Ellen K. Pedersen
1223 Arthur St.
Davis, CA   95616 USA
E-mail: elena@wheel.den.davis.ca.us

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