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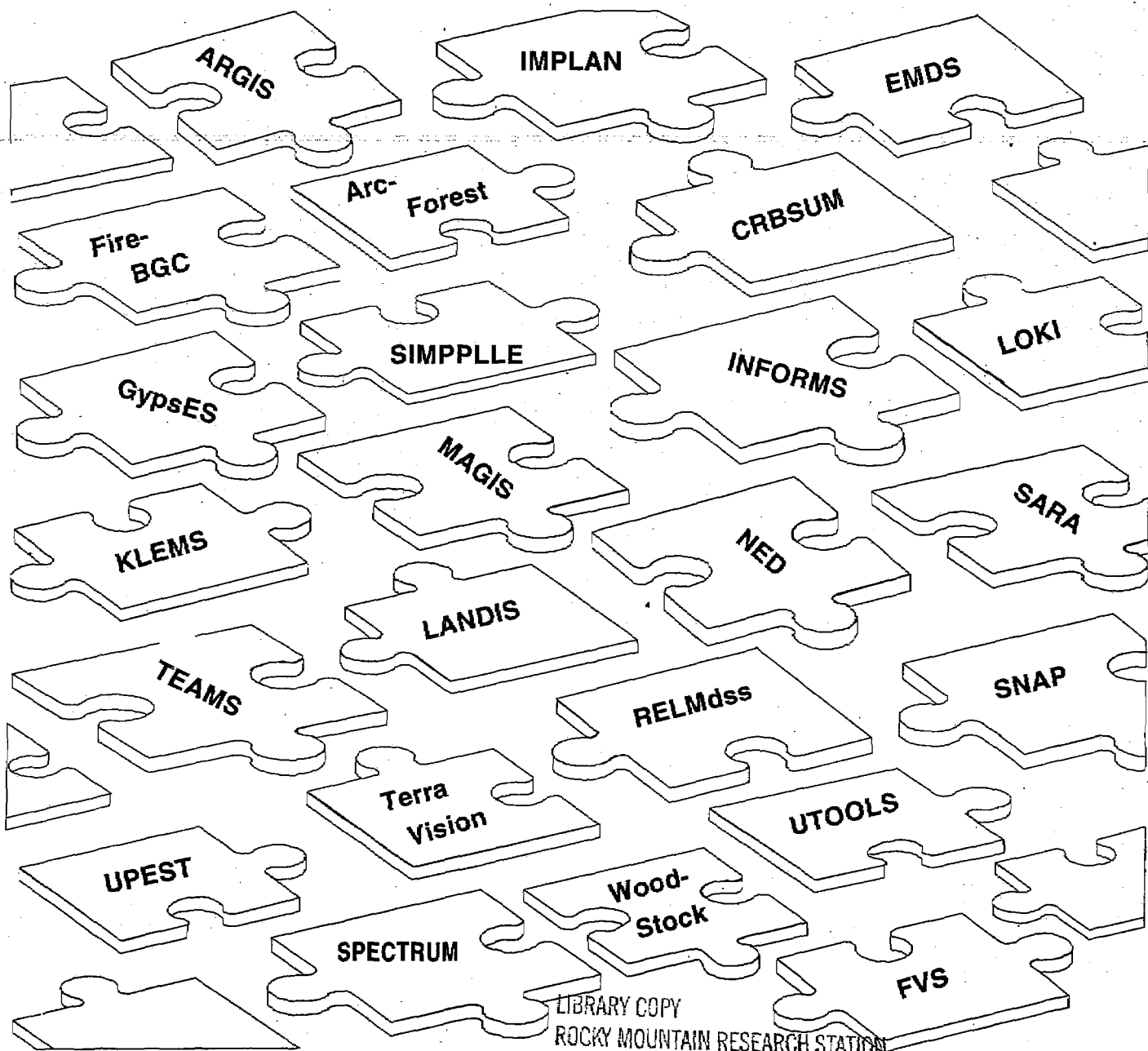
Rocky Mountain  
Forest and Range  
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Fort Collins,  
Colorado 80526

General Technical  
Report RM-GTR-296



# Decision Support Systems for Ecosystem Management: An Evaluation of Existing Systems



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## Abstract

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This report evaluates 24 computer-aided decision support systems (DSS) that can support management decision-making in forest ecosystems. It compares the scope of each system, spatial capabilities, computational methods, development status, input and output requirements, user support availability, and system performance. Questionnaire responses from the DSS developers (who have sole responsibility for their content) provide the basis for four summary tables comparing system capabilities. The responses are also presented verbatim for reference. This evaluation aids potential users of decision support systems in determining which system most closely fulfills their needs.

*Keywords:* geographic information systems, optimization, heuristics, artificial intelligence, simulation modeling

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## The Authors

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## Publisher

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**Rocky Mountain Research Station  
Fort Collins, Colorado**

**August 1997**

*Editor's Note: Due to time constraints, most of this report was not edited. Decision Support System Evaluations pages were composed directly from copy supplied by the technical compiler.*

# Decision Support Systems for Ecosystem Management: An Evaluation of Existing Systems

H. Todd Mowrer, Technical Compiler

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## Preface

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Corporate data and analytical procedures must be available throughout the agency so that different regions in the Forest Service reflect a common approach to ecoregional-scale assessments. Within broad-scale assessments, coherence must be maintained across many interrelated component analyses at multiple temporal and spatial scales. Decision support systems assist natural resource managers in this process.

The Interregional Ecosystem Management Coordination Group (IREMCG) consists of deputy regional foresters and assistant Station, Laboratory, and Area directors meeting together to develop a comprehensive corporate strategy for ecosystem management. As part of the overall IREMCG effort, an ad hoc task team consisting of decision support system users and developers from throughout the Forest Service was assembled. The team met in October and November, 1995, and compiled a list of 48 questions to evaluate existing decision support systems in an ecosystem management context. This questionnaire was distributed to developers of 24 decision support systems. These systems, developed in the government, academic, and private sectors, were recognized by the team as being potentially valuable for ecosystem management activities within the agency. The results of the questionnaires are presented here. This evaluation is intended to assist current and potential users of decision support systems in determining which existing system most closely fulfills their needs. It is also intended to encourage cooperation among developers of decision support systems to more efficiently unify and fulfill these criteria in future systems.

Tom L. Thompson  
Deputy Regional Forester  
Rocky Mountain Region

# Decision Support Systems for Ecosystem Management: An Evaluation of Existing Systems

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## Introduction

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The complexity of making coherent, integrated, and interdependent ecosystem management (EM) decisions challenges human capabilities. These decisions must be legally defensible, while simultaneously anticipating responses and feedback mechanisms between biota and their environment at multiple temporal and spatial scales, accounting for biophysical, social, and economic considerations, and resolving conflicts between special interest user groups (to name a few). Responsible ecosystem management requires an underlying knowledge of ecosystem form and function, the accumulation of qualitative and quantitative information to adapt these conceptual models to a management locale, and the selection of appropriate management options that in some manner optimize the (often conflicting) decision criteria.

Over the past three decades, computer-based information systems have sought to alleviate this burden, even as it developed, through "interactive computer-based systems that help decision makers utilize data and models to solve unstructured problems" or decision support systems (Sprague and Carlson 1982). Decision support systems (DSS) may be interpreted so loosely as to include any system that supports a decision in any way, or so strictly that no system fully satisfies this generic definition. In natural resources, DSS's have evolved to encompass multi-component systems that include various combinations of simulation modeling, optimization techniques, heuristics and artificial intelligence techniques, geographic information systems (GIS), associated databases for calibration and execution, and user interface components (Stock and Rauscher 1996). Each of these six components may to some degree individually satisfy Sprague and Carlson's generic DSS definition. However, in the current study we have tried to review systems that fit this multi-component definition in its entirety, thereby limiting the number of relevant systems. (By comparison, see Schuster et al. 1993 for a compendium of 250 analytical tools for planning at the National Forest level.)

Given the complexity of decision criteria stated above, it is unlikely that a short, simple definition could adequately characterize DSS characteristics necessary for EM. The primary accomplishment of the 1996 DSS task team meetings was to develop and distribute a questionnaire to evaluate DSS tools for their potential to support

ecosystem management decisions. Through this questionnaire, DSS capabilities for EM are defined. We sought to define the unique EM aspects of the "unstructured problem" in the Scope and Capabilities and the Spatial Issues sections of the questionnaire. The questions in these two sections can be interpreted as an extended definition of the issues a DSS must address to be useful for ecosystem management. To further complete the generic DSS definition above, the "data and models" that must be utilized for EM are described in the Inputs/Outputs and Computational Methods sections. The "interactive computer-based" support necessary to tie all these together are delineated in the Basic Development and Status, the User Support, and the Performance sections. Tables 1 through 4 provide a quick reference for comparing system capabilities. In order to formulate these tables, a limited degree of interpretation of the developers' answers was required. Do not rely solely on these tables, but also read and compare the individual questionnaire responses. Brand names are used solely for the convenience of the reader and do not imply endorsement by the U.S. Department of Agriculture.

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## Questionnaire Description

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The questionnaire was distributed by members of the Task Team to developers of 15 Agency, six academic or non-profit, and three commercial decision support systems. The Task Team labored to word each question to minimize misinterpretations, and developers were allowed to review their responses in the context of the entire document. However, there still remains a potential for differing levels of comprehension. Each DSS developer evaluated their own product, provided the text of the response presented here, and has sole responsibility for its content. This approach had advantages in terms of timeliness and efficiency, but also an inherent disadvantage in terms of subjectivity and possible bias. The questionnaire and associated descriptions should be read with these caveats in mind. The verbatim responses in this document have only been edited to provide a common appearance and format to ease comparisons between systems. Any listed prices are in 1996 U.S. dollars

It is also recommended that the reader correlate and compare the responses within the questionnaire for a

Table 1. Scope and Capabilities.

Decision Support System Name Evaluation Criteria	A	A	C	E	F	F	G	I	I	K	L	L	M	N	R	S	S	S	T	T	U	U	W
	R	R	R	M	I	V	Y	M	N	L	A	L	A	E	R	A	S	S	P	E	R	P	W
	C	G	B	D	R	S	P	P	F	L	N	O	M	D	E	A	I	N	A	A	A	O	O
	F	I	S	S	E	S	L	L	S	D	K	A	D	S	S	R	M	P	P	T	R	T	S
	O	R	S	M	B	G	C	S	E	S	I	S	S	S	S	A	P	L	L	R	R	O	S
	R	E	S																				
	E	S	T																				
4) NEPA Issues								X	X					V*					X				
5) Scale: Stand /Project	X				X	X	X								X	X		X	X				
Landscape	X		X	X	X	X	X							X	X			X		X		X	X
District	X		X		X		X																
Forest			X		X																		X
Ecoregion			X					X															
Data Dependent		X	X	X				X	X	X	X	V*			X	X	X	X	X		X		X
6) Regionally Specific Calibration			X	X	X	X				X	X	V*		X		X	X	X		X	X		
7) Social Analyses		I*					I*		V*				V*	I*	V*	X		V*	X	V*	V*	V*	V*
Economic Analyses		I*					I*	X	V*				V*	X	V*	X		V*	X	V*	V*	V*	V*
Biophysical Analyses	X	I*	X	X	X	X	X	X	X	X	X	V*	X	X	V*	X	X	V*	X	V*	V*	X	V*
8) Analyze Current Conditions	X		X	X	X	X	X	X	X	X		V*	X	X	X	X	X	X	X	X	X	X	X
9) Predict Future Conditions			X		X	X	X	X	X		X	V*	X	X	X	X	X	X	X	X	X		X
10) Alternative Comparison	X	X	X		X	X	X	X	X			V*	X	X	X	X		X		X	X		X
11) Public Participation		X			X		X					V*		X	X	X							X
12) Consensus Building		X										V*				X							X
13) Monitoring/Feedback					X							V*			X								
14) Distributed Processing																							X

(\*I implicit, not explicitly handled, \*V varies by user application)

Table 2. Spatial Issues (15-19) and Basic Development and Status (20-28).

Decision Support System Name Evaluation Criteria	A	A	C	E	F	F	G	I	I	K	L	L	M	N	R	S	S	S	T	T	U	U	W
	R	R	R	M	I	V	Y	M	N	L	A	L	A	E	R	A	S	S	P	E	R	P	W
	C	G	B	D	R	S	P	P	F	L	N	O	M	D	S	A	I	N	A	A	A	O	O
	F	I	S	S	E	S	L	L	S	D	K	A	D	S	S	R	M	P	L	L	R	R	S
	O	R	S	M	B	G	C	S	E	S	I	S	S	S	A	P	L	L	R	R	O	S	
	E	S	T																				
	R	E	S																				
15) Analytical/Spatial Relationships	X			X	X		X		X	X	X	V*	X		X	X	X	X	X		X	V*	X
16) Spatial Alternatives	X	X	X	X	X		X		X		X	V*	X		X	X	X	X		X		X	
17) Multiscale Interactions					X	X						V*			X	X	X		X				X
18) Scale-appropriate Support				X			X		X			V*		X	V*	V*		V*					
19) Spatial Transformation (T), Aggregation (A), or Both (B)			A	T	A	B	A		V*	T	A	V*		B	B	A	B			B	V*		
20) Status: Conceptual/Prototype				X								X					X						
Partially Operational		X											X	X									
Fully Operational	X	X	X		X	X	X	X	X	X	X				X	X		X	X	X	X	X	X
21) Successful Current Users	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X		X		X
22) Platform: Workstation/UNIX	X		X		X	X	X		X	X	X	X					X				B*		
Personal Computer		X		X		X		X		X	X	X	X	X	X	X	X	X	X	X	B*	X	X
23) Additional Hardware Required	X	X	X	X	X		X									X							
24) Additional Software Costs	X	X		X						X	X		X		X	X	X		X	X	X	X	X
25) On-going Maintenance Costs	X	X											X										
26) Development/Enhancements	X	X		X	X	X	X		X		X	V*	X	X	X		X	X		X			
27) High Learning Curve		X	X		X	V*					X	V*				X					X		
28) Agency Database Independence	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X

(\*V varies by user application, \*B requires both computer platforms.)

Table 3. Inputs/Outputs (29-37) and User Support (38-43).

Decision Support System Name	ARCFORREST	ARGIS	CRBSUM	EMDS	FIREBGC	FVSE	GYPSES	IMPLAN	INFORMS	KLFORMS	LANDIS	LOKI	MAGIS	NEED	RELMDS	SARAS	SIMPPLLE	SNAPP	SPECTRUM	TEAMSVIS.	TERRAVIS.	UPEST	UTOOLS	WOODSTOCK
29) Import/Export Database Files				X			X	X	X	X	X	V*	X	X	X	X		X	X		X	X	X	X
30) User-designed inputs		X	X					X	X			V*	X	X		X		X				X	X	X
31) Data Required: Current Data (C), New Data (N), Requires Both (B), or Runs with Either (E)	E	E	N	B	N	E	B	B	E	E	B	V*	N	E	E	E	B	E	E	E	E	C	C	E
32) Run with incomplete data				X		X	X		V*		X	V*		X				X						
33) Directly to Arc/Info and Oracle	X								O*	X	A*	V*	X					X			X		X	
34) Internal Visualization Graphics	X	X		X			X		V*			V*		X	X	X		X			X		X	X
35) Report Generation	X		X	X	X	X	X	X	V*	X	X	V*	X	X	X		X	X	X	X	X	X	X	X
36) System-interpreted Outputs				X								V*					X						X	
37) Coefficients or Knowledge Bases Fixed (F), User-defined (U), Both(B)			B	B		B	B	B	B	U	U	V*	U	B			U		F	B	U	F	B	U
38) Training Available	X					X	X	X		X					X	X		X	X					X
39) User Support	X				X	X	X	X	X	X				X	X	X		X	X	X		X	X	X
40) On-line Help within System	X	X		X			X			X			X	X				X						X
41) Activity Log or Data Lineage		X		X	X	X	X	X	X	X		V*	X	X	X		X	X	X	X	X			X
42) Explanation Facility*				X			X		X	X		V*												
43) User and Support Manuals	X		X		X	X	X	X	X					X	X	X		X	X					X

(\*Explanation Facility applies primarily to knowledge-based systems, \*O Oracle database only, \*A Info database only, \*V varies by application)

Table 4. Performance (44,45) and Computational Methods 46, 47).

Decision Support System Name	ARCFORREST	ARGIS	CRBSUM	EMDS	FIREBGC	FVSE	GYPSES	IMPLAN	INFORMS	KLFORMS	LANDIS	LOKI	MAGIS	NEED	RELMDS	SARAS	SIMPPLLE	SNAPP	SPECTRUM	TEAMSVIS.	TERRAVIS.	UPEST	UTOOLS	WOODSTOCK
44) Analysis Run Time:												V*												V*
Less than 60 Minutes	X	X		X		X	X	X	X	X				X	X	X	X	X	X	X		X		X
Less than 24 Hours	X				X	X		X			X		X							X	X			
Several Days			X										X											
45) Data set-up for an application:												V*												V*
Hours						X		X	X		X			X	X									X
Days				X			X	X		X			X	X			X	X				X	X	
Weeks		X					X	X									X	X	X		X			
Months		X	X		X												X		X		X			
46) Modeling Techniques:									V*			V*												
Simulation					X	X	X	X		X	X			X		X	X		X		X	X	X	X
Optimization													X		X	X			X	X	X			X
Knowledge-Based						X	X			X				X			X	X						X
Fuzzy Logic										X				X		X								
47) Explicit System Evaluation of:												V*												
Accuracy of Estimates						X																		
Error Propagation						X																		
Uncertainty and Risk						X											X		X					X
Sensitivity Analysis							X							X		X			X					X

particular DSS tool. The desirable capabilities presented in one section may be offset by practicalities (e.g., the current level of system development, required user expertise, or computer requirements) presented in other sections. Tables 1 through 4 provide an interpreted comparison of the capabilities of these DSS's in matrix format. They may be useful for comparison of overall capabilities and selection of a few DSS tools for a more complete evaluation. A critical reading of questionnaire responses for these tools is necessary for an informed DSS selection.

## Scope and Capabilities

As described above, the scope and capabilities section reflects the ability of the DSS to provide support in decision areas unique to EM. The explicit capability to comply with National Environmental Policy Act (NEPA) regulations are addressed in question 4. While several DSS's may address these if properly formulated, this question is intended to single out those with explicit capabilities to aid in fulfilling NEPA requirements. Question 5 only deals with individual scales at which the DSS can operate, and does not address the ability to function at multiple scales simultaneously. Responses to question 5 need to be read carefully and correlated with responses to question 17 regarding multi-scale interactions. Those systems for which scale is indicated as being "data dependent" are capable at operating at any scale implicit in the user's data. Those for which individual spatial scales are indicated, are specifically designed to operate at those scales. Temporal scales or time-steps are not specifically addressed because relatively few systems involve temporal simulation. If used, the time step should match with scale and overall context.

In this document, "ecoregion" is used generically to mean coarser spatial aggregations, e.g., section or province (Bailey et al. 1994). The term "region" was avoided because of confusion with Agency administrative units. Regionally specific calibration (question 6) asks if there are coefficients embedded in the DSS that have been calibrated to a specific locale, and that would require recalibration if the DSS is applied elsewhere. Answers to question 6 should be correlated with question 37 regarding coefficients or knowledge bases. Question 7 seeks to highlight DSS's with the capability to deal with social, economic, and biophysical aspects explicitly, though an ability to do so either indirectly (implicitly) or through proper formulation is also indicated. While all DSS's require some indication of current conditions for initialization, questions 8 and 9 ask whether they are further analyzed in some manner. Question 10 asks if the DSS easily provides for the comparison of alternative scenarios, or if the DSS must be separately initialized for each. For example, alternative comparisons would be facilitated by

the ability to generate a series of reports by automatically incrementing a parameter through a predetermined range. Question 10 should be evaluated in conjunction with question 16 regarding spatial alternatives, and question 47 regarding sensitivity analysis. Results from virtually any DSS can be displayed on a projection device and used to display a previously prepared decision scenario to a public gathering. However, question 11 asks whether the DSS is designed to interact in real-time with public participation ("what if ..." interactions, for example), and whether the DSS has capabilities to display these alternative comparisons to aid in the evaluation of trade-off's. Question 12 deals with the capability of the DSS to aid in building group consensus through some mechanism such as facilitated interaction. Question 13 is intended to determine if the DSS has the capability to assist monitoring activities. An example of this would be to hold projected or expected values in the database and compare these with actual data, usually obtained at a later date and subsequent to a management activity. Question 14 asks if the DSS tool is capable of working interactively across multiple locations simultaneously (e.g., through a shared database). The DSS would thereby help ensure coherent sets of tactical decisions at a finer spatial scale with regard to aggregated effects on strategic goals at a coarser scale (e.g., ecoregional level).

## Spatial Issues

This section involves some of the most complex and difficult questions. The Task Team concluded that the ability to assist and support decisions, not simply in a spatial context, but at multiple spatial scales simultaneously, is a critical element in successful ecosystem management. Question 15 asks if the system has unique and useful spatial analysis tools. While any DSS that includes a fully functional GIS fulfills this criteria at a basic level, the question further seeks to elucidate systems that have more sophisticated spatial analyses. Such systems can help assess the juxtaposition of multiple ecosystem components. Examples of this would be the ability to calculate spatial statistics, pattern analyses, or metrics of landscape structure. This capability aids in making meaningful comparisons between different ecosystem components within a particular scale, and in performing spatial analyses on the same component occurring at multiple scales. Question 16 specifically addresses analysis of spatial alternatives (question 10 is more generic). Systems that have the capability to analyze and display multiple spatial alternatives fulfill the basic requirement.

Question 17 is a key question for EM: can the system take into account data and analyses occurring simultaneously at several other scales when supporting a decision. Few, if any, systems address the full complexity of



this issue, though many have simple abilities to aggregate from one scale (e.g., individual tree) to another (e.g., stand averages). When interpreted as requiring that the system maintain coherence over multiple interacting and interrelated activities at multiple scales, this becomes a very difficult criterion to fulfill. An ideal system fulfilling the intent of both questions 14 and 17, could integrate the ongoing effects, say on sedimentation, of multiple site-level projects occurring throughout all the Districts within the major watershed draining the entire ecoregion. This capability could be extended to multiple scales, to account for contributions (to sedimentation, for example) at intermediate scales ensuring compliance at these levels, also.

Question 18, regarding scale-appropriate support, is similarly complex. The ability to provide prescriptive, allocative, and policy decision support and advice at multiple scales is also very difficult to fulfill in more intricate management scenarios. Question 19 asks how data are moved between scales. In the example of individual tree data, simple aggregation works well for absolute numbers of stems or total biomass, for example. Transformations may be complex, however, in the case of the point pattern of tree characteristics within a stand, versus the distribution of equivalent stand characteristics across a landscape.

## Basic Development and Status

This section deals with the straightforward description of the level of completion, costs, hardware and software sophistication, and widespread use of systems. Question 20 separates out those systems that are fully complete from those in developmental stages. It does not address the need to calibrate particular sub-models, processes, or knowledge bases to particular locales, however (see questions 6 and 37). This may require substantial investment before the system will be fully functional in a different location. Question 21 provides potential contacts with those who have successfully used the system. Question 22 deals with the platforms (both operating systems and hardware) required to support the system. It is particularly useful for determining systems that can run on a personal computer, versus those that require the resources of a workstation. Questions 23 and 24 ask if additional hardware or software costs must be incurred to operate the DSS. For personal computers, this would consist of items in addition to a basic or generic configuration. This may be relatively inexpensive: upgrading the system memory or disk storage, for example. Some DSS require the purchase of a particular piece of vendor-specific software because this software provides the analytical engine for the DSS, e.g., optimization. Depending on the software, license fees can be expensive, however, so detailed inquiry is worthwhile. On-going maintenance costs

(question 25) deals primarily with yearly maintenance costs for licensed software. In systems developed in the private sector, this may be for the DSS software itself. In other systems, it may be fees for component software. Question 26 generally asks whether the system is static and complete, or whether future enhancements to functionality are planned. Question 27 generally deals with the complexity of learning the system: whether the end user can operate the system, whether it requires some degree of sophistication or specialization (in computer systems or GIS, for example), or whether it requires outside assistance to develop an application and run analyses. The relative availability and economic advantage of within-Agency expertise versus external contracted expertise should be considered. Question 28 asks whether the system operates exclusively on Agency databases, or whether the database is generic (non-Agency dependent). (See also questions 22, 31, and 33.)

## Inputs and Outputs

This section describes the types of input data required to initialize the system, what sorts of internal calibration data may be required, and the types of outputs the system will produce. Question 29 asks if the system can import or export any accepted database format widely used by software packages (see also question 33). Question 30 asks if the user can define the format of input data and outputs. This feature helps minimize re-formatting of existing data. Question 31 attempts to determine if the system requires that new data be collected, or whether it will run on data that has been collected in the course of Agency business, or perhaps exists elsewhere in the public domain. The former would imply that some degree of data collection must be initiated to utilize the system. Examples of the latter include Stand Exam data used to evaluate current forest stand conditions and to project future stand development. Question 32 asks if the system will operate without complete data. Many systems will not operate unless all error checking procedures in the input routines are satisfied. More sophisticated systems may attempt to substitute generic values or to provide some degree of interpolation across missing values. These systems usually provide an indication of the limitations of recommendations based on incomplete data. Question 33 again addresses Agency compatibility, to the extent that the system will import or export directly to Oracle or Arc/Info data formats. Question 34 asks if the system has internally coded routines to display graphical outputs such as simple graphs and bar charts or more sophisticated maps and scientific visualization techniques. Systems that simply provide outputs that feed displays by other graphical software packages would therefore not qualify. Question 35 asks for descriptions of the tabular reports provided, if any. Question 36 deals

with the degree to which the output is interpreted by the system. Systems with knowledge-based components are generally more amenable to providing interpreted outputs. Question 37 addresses internal coefficients or knowledge bases within the system: Are they fixed ("hard coded") within the system, must they be user defined, or may they be changed at the user's option (see also question 6). Coefficients or knowledge bases that must be provided by the user may incur additional hidden costs for data collection and calibration.

## User Support

This section gauges the degree and sophistication of the assistance provided the user for implementing and operating the system. Question 38 indicates if some level of formal training is available. Sophistication and cost of these sessions vary widely. A full level of training support might consist of formal training sessions offered at least annually, with established course materials. Telephone "hotline" support is the most common form of user support indicated by Question 39. This may vary from access to full-time personnel trained specifically for the task, to catching the system developer in their office. On-line support within the system generally involves some sort of "help" feature, either through "pop-up" windows, or other forms of documentation available electronically on the computer platform. An activity log (Question 41) keeps track of the commands and system responses throughout a session, while tracking data lineage may be very useful for complex spatial analyses involving the creation and interaction of many spatial data sets during a session. The explanation facility in Question 42 is most often provided in knowledge-based systems, often through "hyper-text" windows that allow analytical procedures and lineages to be explained and formally documented in a hierarchical context. User and support manuals, indicated in Question 43, are the most basic and universally accepted type of user support.

## Performance

System performance is primarily addressed by the actual length of time it takes the system to perform a "typical" analysis. Answers to question 44 may also indicate a range of times, depending on the sophistication of the analysis. Similarly, the length of time required to set up an application in question 45 may have a range of answers, depending not only on the complexity of the analysis, but on the type and quality of the data available. It should be noted that user sophistication and data quality, have a great affect on the variability in start-up time to initiate an analysis with a particular DSS.

## Computational Methods

A DSS may utilize one or more methods to arrive at system recommendations. Deterministic simulation provides a single consistent value when the same decision process is repeated. Stochastic simulation provides different values that range across a distribution of possible outcomes. Optimization techniques usually compute the local or global minimum or maximum value of some function or relationship, subject to various constraints. Inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning are all generally classified under artificial intelligence techniques, and provide methods for dealing with qualitative information, not amenable to traditional numerical techniques. Question 46 asks for a list of these techniques as utilized by the system.

The well engineered DSS should also provide an indication of the reliability of the projected result or recommendation (question 47). Accuracy assessment is generally associated with the categorical or numerical accuracy of classified or sampled input data. How this inherent uncertainty in input values propagates through the decision support analysis and how internal uncertainties in calibrated coefficients or knowledge bases affects system reliability is dealt with through error propagation techniques. In artificial intelligence techniques general uncertainty assessment may occur on an *ad hoc* basis through computation of "certainty factors" intended to gauge the certainty of a basic datum or outcome, or through more rigorous methods, such as Bayesian statistics. Uncertainty and risk assessments have in the past been associated with single-factor types of analyses, such as toxic waste studies. The multi-factor spatial and temporal aspects of EM decisions compounds the complexity of risk analysis and has not been well addressed to date. Sensitivity analysis is the simplest form of uncertainty assessment and generally involves randomly or systematically varying a single parameter, while measuring the effect on the final outcome (with all other factors held constant).

Question 48 asks for specific capabilities or strengths that are not covered by the previous 47 questions.

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## Conclusions

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At least one of the systems evaluated fulfills each criterion at some level of complexity. Multi-scale interactions (question 17) and distributed processing (question 14) are key issues for biophysical aspects of EM, but are not comprehensively addressed by any of the systems evaluated. The ability to address social and economic issues lags far behind biophysical issues, and leaves the question of

simultaneously addressing all three to future development. Many questions regarding appropriate mechanisms for aggregating and transforming data between scales remain unanswered, also. Consensus building remains a high priority in developing EM scenarios, but is well addressed by only one of the systems, which is highly dependent on trained facilitation personnel. While all of these issues may be addressed with some degree of success by different systems, no single system addresses all questions with even average success. Should a single DSS attempt to address all of these questions successfully? Perhaps not, however questions five through nineteen delineate a general set of goals for systems to strive towards through innovative research, efficient development, and pragmatic consolidation.

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# **Decision Support System Evaluations**

# ArcForest

## 1) System/tool Name: Title or acronym of tool.

ArcForest - Forest Management Decision Support System product

## 2) Brief description: Short statement of purpose and functions.

ArcForest is an Arc/Info and Oracle-based software product comprising a set of integrated functions to support forest management planning and improved decision-making for managing forest land. ArcForest's functions are organized into Modules and Sub-processes and include: Forest and Land Records Management, Query, SurfaceView, MapComposer, Planning-Eligibility, Planning-Define Planning Area, Planning-Allocation, and System and Data Administration. Together, these processes provide a forest vegetation inventory and maintenance system and support for strategic and operational management for harvesting and silviculture and roads planning.

## 3) Developer/Contact: Name, Organizational unit, address, phone.

ESRI Canada Limited

Product Manager: Keith Jones, ESRI Canada - Victoria

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## Scope and Capabilities

### 4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.

It is unlikely that ArcForest can handle NEPA criteria explicitly. Rather, ArcForest provides the user with a set of integrated spatial and tabular tools that can be used to query and analyze existing spatial and tabular forest land information in a flexible manner.

### 5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?

ArcForest has been designed for use primarily at a "district" and management unit level for planning and inventory maintenance in an organization. While quite variable, this could involve land areas typically ranging from 50,000 ha. to 1,000,000 ha. in size. ArcForest works mainly with information at the stand (and sub-stand level) and their stratification into various management units, administrative components and map sheets.

### 6) Geographic region applicability: In what areas will it work? Is it limited without major modification?

As a product, ArcForest aims to be applicable to many forest regions and forest management situations worldwide. With each release, increasingly more generic approaches are introduced so that the product is more easily adapted to specific requirements. ArcForest provides a sound database framework, adapted to forestry practices for stand-based management and services as an extendible application development environment.

We differentiate between three components in the ArcForest product: Core, Shell, and Extensions. The Core forms the nucleus and comprises the primary data structures and business functions. ArcForest Shells and Extensions work in unison with the Core to handle data model extensions and business processes specific to a particular jurisdiction, region or the requirements of a large organization. For example, a Shell would include facilities to load digital government files and to generate standard map and report products. Extension to ArcForest are typically very organization-specific whereas Shells are for a sub-market (e.g., tropical) or a very large organization (e.g., US Forest Service). ArcForest is being

used operationally in Ontario and is in the process of being implemented in Ecuador and Malaysia. For these installations, a Tropical Forestry Shell will be developed for ArcForest.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

ArcForest concentrates mainly on the management of forest (biophysical) resources. In so doing, it has been designed to incorporate and with other related land information such as roads, drainage, terrain, wetlands, wildlife and various ego-administrative units. Similarly, related social and economic information can be associated with existing ArcForest coverage's and linked (i.e., related) to core tables as extensions.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

ArcForest provides the capability to organize spatial, tabular and temporal forest and related land information. It includes a number of standard reports such as "Productive Forest Report" and "Forest Class Report" (see also question 35). These reports and associated map products provide on form of assessment of current conditions, assuming the database is being maintained. ArcForest does not include in the current release direct assessments (i.e., models) for site and landscape qualities like "biodiversity". However, ArcForest does provide a development environment (ArcForest Programmer's Course and Guide) and framework for linking-in such assessment models (see also Tour Guide description in question 43).

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

ArcForest has a "Grow Forest" function, which is currently used as an optional means to update an out-of-date forest inventory. Again, our emphasis with the product has been to focus on providing a sound enabling infrastructure for such forecasting models. The next release will contain the capability to project forest growth (mensurationally) as a predictive tool. With respect to predictions, we are working on a pilot project with a forestry software company (Remsoft Inc.) to link ArcForest to their strategic planning model (Woodstock) and tactical harvest blocking model (Stanley). Please see attached information on Remsoft software.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

ArcForest allows the user to develop more than one planning alternative - Management Scenarios. ArcForest's Planning process is quite structured - hierarchical and sequential. For example, a forester might choose to develop a plan based on different Eligible Forest criteria - one which includes certain land conditions and one which excludes these criteria. Similarly, users can make multiple copies of the same Eligible Forest and work through different classification and allocation strategies with each copy. Feature criteria that can be included in this hierarchical process are mainly stand properties (age of origin, species composition, productivity, etc.) and administrative strata. Social and economic factors are not handled explicitly but could be with table and business process extensions. Maps and reports associated with ArcForest's planning process allow for comparison of different scenarios, although this stage are no automated comparative analysis tools per se.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

ArcForest is being used to support the public participation process in Ontario. It is being used in advance of the meetings to prepare a range of map products that display a proposed forest management plan. ArcForest was not designed to display and test alternatives "on-the-fly" in a highly interactive environment. We see this type of requirement being met more by an associated ArcForest application using ArcView (our prototype applications is called "ForestView").

**12) Consensus building capability: Is explicit consensus-building methodology included?**

Not explicitly, but consensus building can be accomplished via comparison of multiple scenarios with involved parameters at each iteration (see question 10 also).

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

In the current release, ArcForest has no explicit functions that allow the user to obtain comparison of actual with expected values. However, there is the ability to store alternative in the database for comparison later. ArcForest's database structure uses transaction processing as a means to capture forest activities and forest changes over time. Maintained as a series of tabular and spatial transactives, the database is able to capture aspects of forest history. In future releases of ArcForest, history and monitoring analysis tools and reports are being planned but more detailed user requirements are required prior to building these tools.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

ArcForest is a unix-based, multi-user system that can operate in a shared networked environment. Planning scenarios created in the form of selection lists, reports and maps can be assessed and shared.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

ArcForest has a set of spatial functions that allow you to query, display and save these types of relationships. Within the ArcForest environment the user has access to buffer and overlay tools which can work with either coverages or other saved selection lists. Together, these tools provide the basis for the user to do corridor, fragmentation and habitat relationship types of analyses. There are no "forest fragmentation buttons" per se, in the product. Features like this could be created as a custom feature (see description of Programmer's Guide in question 43).

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

Yes, ArcForest allows the user to display and work with the database in an integrated spatial and tabular manner. Linking spatially-explicit planning models would add to ArcForest's base capabilities in planning (see question 9).

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

No. Because the database structure can be cross-referenced with a number of (sometimes hierarchical) spatial geo-administrative units, ArcForest is able to handle aspects of inter-level relationships such as regions <-> districts <-> management units.

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

Not explicitly. The intent of ArcForest is to provide decision support at the operational (e.g., 5 year plan) and strategic level (over at least one rotation). To the extent that policy decisions can be translated into rules, regulations and constraints on planning at these levels, then ArcForest can be used to determine the potential ramifications.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

At this stage, there are not data transformation functions in relation to the different planning levels or scales. Cartographically, certain map generalization functions will be accomplished via ArcView in an

ArcForest-Arc/Info//workstation <=> "ForestView" (prototype applications)- Arc/Info// pc environment.

## Basic Development/Status

### 20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?

Operational, Version 1.3(7) using Arc/Info 7.x and Oracle 7 on four hardware platforms - Sun, DEC, HP, IBM. Development activities continue towards further releases.

### 21) Current users: List existing successful applications and users.

Ontario Ministry of Natural Resources

Kirkland Lake District

Box 129 (Hwy 66 & 112)

Swastika, Ontario, Canada P0K 1T0

Contact: District Manager - Ron Kervin, GIS Analyst - Paula Klockars

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Has been used to update forest inventories for over 100 map sheets that had not been updated since 1986 and has and is being used to develop management plans with associated maps and reports. ArcForest has been purchased by Abitibi Price, Thunder Bay, Ontario. They are currently in a data load stage. The plan to use ArcForest for inventory maintenance and to support their management planning activities. ArcForest has been purchased recently by Instituto Ecuatoriano Forestal de Arcas Naturales y Vida Silvestre (INEFAN) Ministerio de Agricultura ["Department of Natural Resources for Ecuador"] and an implementation plan is underway. ArcForest has also been purchased by the Sabah (Malaysia) Department of Forestry and a pilot project under the Sabah Forest Management Information System initiative is underway. ArcForest is being used in an educational context by Sir Sanformed Flemming College, Lindsay, Ontario in the natural resources management - GIS program. In 1995, approximately 20 students used ArcForest in a 14 station laboratory to develop different planning scenarios and to learn about the concepts of spatial forest management decision support.

### 22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)

ArcForest has been successfully ported to other UNIX hardware and associated operating systems. The porting effort is typically 3 weeks, most of this time being spent on testing. See also question #20.

### 23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?

ArcForest is available on SUN running SUN OS Ver. 4.1.3 (Solaris 1.1.1), DEC Alpha running OSF/1 Ver. 3.2. HP 700 running HP-UX Ver. 9.05 and IBM RISC 6000 running AIX. All platforms require a minimum configuration of 600 Mb available disk space; 48 Mb RAM, 200 Mb swap space; Arc/Info Rev. 7.0.3., Oracle Rel. 7.0.6. and Oracle Forms Rel. 3.0 are bundled with the ArcForest license. The SurfaceView Module requires Arc/Info TIN.

### 24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)

Please see question #23 also. ArcForest is priced at US\$43,500 per license. Each license can have up to 3 concurrent users, and includes Oracle (2 Runtime and 1 Application-Specific Developer License) and the first year warranty-maintenance. Discounts apply for 2-10 (30%) and >10 licenses (40%). No pricing structure for US government agencies has been established yet.

### 25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?

The annual maintenance fee is US\$6,000; discounts with volume.



**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

As a product, ArcForest will continue to be developed by ESRI Canada. Organization-specific developments outside of the Core product can be covered by a services contract with either ESRI Canada or our Accredited partners. New versions (minor enhancements, bug fixes, upgrades related to new releases of the enabling technologies) of ArcForest occur at least annually. Major releases involve more significant improvements to the technology and occur every two years.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

ArcForest has two types of users: forestry-natural resources professional or technician - on a daily basis, ArcForest has been designed for use in a non-technical user for functions like inventory database maintenance, ad hoc querying and planning. This level of use requires little to no knowledge of Arc/Info, Oracle or Unix. ArcForest systems administrator - the systems administrator is unlikely to work with the system daily but would be involved with data loading, linking-in external models and processes and controlling the system use (Administrative Module). The systems administrator should have a working knowledge of Unix; Arc/Info, Arc/Info Librarian and AML; basic experience with SQL and Oracle; and knowledge of digital conversions of both spatial and tabular data.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

Please see answer to question 6.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Import formats spatial: Arc/Info or Arc/Info importable coverages including ArcView generated Shape files. Import formats tabular: standard import formats (e.g. ASCII) to load into Oracle tables. Exports: any selection list can be converted and expressed spatially as an Arc/Info coverage (once in Arc/Info format is in-turn can be exported in a number of standard formats); any selection list can be exported as an ASCII file. All ArcForest coverages and tables are directly accessible and useable by ArcView 2.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

No, not at this stage. Currently this is handled with the addition of extension tables or as part of linking of model to ArcForest. For the purposes of demonstrating a model linkage, an ArcForest Harvest Schedule Generating (HSG - Canadian Forest Service) Module was prototyped. The HSG model was involved from the ArcForest "Models" button and included an HSG interface for specific inputs, outputs and to parameterize a model run.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Traditional existing data. New field data obtained for inventory updating can be entered into the system.

**32) Incomplete data: Will the system run with incomplete data?**

Some data are mandatory in ArcForest and if absent, certain processes will fail. A number of data integrity and validation checks are made during data load and in the Update Module.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

ArcForest is based on Arc/Info and Oracle technologies and therefore is able to incorporate databases in this form. ArcForest's current data structure will likely require some import and export facilities be created. A top priority for the next major release of ArcForest is to have improved data model flexibility so that existing corporate data structures can be handled more easily.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

A number of user-definable (Views) map displays and plots can be created using ArcForest. In SurfaceView, the ArcForest database layers can be displayed and output on a TIN base. Any lists generated in ArcForest can be exported and used with different graphing and charting software (see question 29 also).

**35) Report generation: Describe the types of reports generated.**

Please see list below of standard ArcForest reports. Custom reports can be created but require programming. Ad hoc reporting capability will be a feature for the next major release of ArcForest. ArcForest provides a number of standard reports to get a user started. These reports can be use as initial templates for the development of organization-specific custom reports.

**A. Planning-Eligibility Reports**

There are five reports available in the Eligibility process of the Planning Module:

- Productive Forest report
- Production Forest report
- Forest Unit report
- Harvest Eligibility report
- Silviculture Eligibility report

**i. Productive Forest report**

This report provides a summary of the land base being managed. It divides the total managed area into the component areas of water, forested and non-forested land, productive and non-productive forest, and production and non-production forest. Three types of forest are used in these reports:

- Productive Forest - consists of all forest areas capable of growing merchantable timber.
- Protection Forest - consists of all the productive forest managed for reasons other than timber production.
- Production Forest - consists of all productive forest after the protection forest is removed.

You can choose to report on an individual owner class or for all owners. You can also specify the starting date for the report and the period of time the report should cover. You do not have to create an eligible forest to run this report.

**ii. Production Forest report**

This report shows the age-class distribution for each working group in the production forest area. A working group is made up of stands sharing the same predominant species. This report tell you the amount, by age, of each working group in the production forest. You can specify the age class interval used in the report (5, 10, or 20 years) as well as the starting date and the period of time the report covers. You do not have to create an eligible forest to run this report.

**iii. Forest Class report**

This report provides you with a summary of the maximum allowable depletion land base area by Forest Class and age class. You have to define a set of Forest Classes in the eligible forest, their make up, size and estimated volume of wood they contain. You can specify the age class interval used in the report (5, 10, or 20 years) as well as the starting date and the period of time the report covers.

**iv. Harvest Eligibility report**

This is a report on the harvest eligibility lists you have created for an eligible forest. You have to set up these harvest eligibility lists before you run this report. It provides you with a stand-by-stand summary of the harvest eligibility area, including details like species composition, age, and area. The Harvest Eligibility report is meant to be used in conjunction with the Harvest Eligibility Map. The information in this report is summarized by age class and Forest Class according to the classification you set up for the map.

**v. Silviculture Eligibility report.**

This is a report on the silviculture eligibility list you have created for an eligible forest. You have to set up this list before you can run this report. It provides you with a stand-by-stand summary of the silviculture eligibility area, including details like species composition, age, and height. The Silviculture Eligibil-

ity Report is meant to be used in conjunctions with the silviculture map. The information in the report is summarized by age class and stand type, for example as barren or scattered or NSR (Not Sufficiently Regenerated), according to the classification you set up for the map.

## B. Planning-Allocation Reports

### i. The Forecast of Depletion by Area report.

This report provides a summary of the area allocated for harvest. It shows, Forest Class and age class, the area which has been allocated for depletion using three categories:

- normal: these are areas where the normal harvest method does not require any modification.
- modified: these are areas where the normal harvest method is being modified for some reason, such as the protection of an identified wildlife habitat.
- reserves: these areas are unavailable for harvest because harvest operations in the area would conflict with another management objective.

The forecasted depletion area is then compared to the maximum allowable depletion area so that a manager can quickly see how close they are. You can choose the age class interval (5, 10, or 20 years) and also the starting date and the period of time covered by the report. An allocation must exist before this report can be run.

### ii. Silviculture Forecast report

This report provides a convenient summary of the area allocated for silviculture treatments. It summarizes the operations in three categories:

- recent cut-over: this indicates that the area consists of stands that were recently cut, but have not yet been treated or classified as barren and scattered (B&S) or not sufficiently regenerated (NSR).
- B & S: this indicates that the area consists of stands that are "barren and scattered".
- NSR: this indicates that the area consists of stands that are "not successfully regenerated"

You can choose the age class interval (5, 10, or 20 years) and also the starting date and the period of time covered by the report. An allocation must exist before this report can be run.

### iii. Forecast of Volume Estimates report

This report provides a summary of the area allocated for harvest. It gives the volumes by wood type (conifer and hardwood) and Forest Class, which are estimated to be available on the area allocated. You can choose the age class interval (5, 10, or 20 years) and also the starting date and the period of time covered by the report. An allocation must exist for this report to be run.

### iv. Stand Summary of Harvest Allocation report

Each map produced by ArcForest has a corresponding report which details the information shown on the map. The Stand summary of Harvest Allocation report is paired with the Harvest Allocation map. It provides you with information for the stands in the allocation and a summary by treatment area, treatment type and map sheet.

### v. Stand Summary of Silviculture report

This report is paired with the Silviculture Allocation map. It provides you with information for the stands in the allocation and summary by treatment area, treatment type and map sheet.

## C. Planning-Eligibility Maps

These maps provide you with graphical representations of any eligibility lists that are created. There are four maps for the eligibility process.

### i. Harvest Eligibility map

This map is a geographic representation of the harvest eligibility lists. It is used in conjunction with the Harvest Eligibility report. It lets you see the spatial distribution of the areas eligible for harvest. The map is shaded using the classification you define for it. A harvest eligibility classification is a color scheme which helps you identify stands according to their Forest Class and age class. You will get a chance to design a classification and generate a Harvest Eligibility map in the exercise which follows. You can only produce this map if you have generated a harvest eligibility list.

### ii. Silviculture Eligibility Map

This map is a geographic representation of a silviculture list. It is the companion for the Silviculture Eligibility report, showing you the spatial distribution of areas eligible for silviculture. Like the Harvest Eligibility map, the Silviculture map is shaded using the classification you define for it. However, the color scheme for a silviculture classification identifies stands according to their stand type and age class,

not their Forest Class and age class. You can only produce this map if you have generated a silviculture eligibility list.

iii. Forest Resource Inventory map

This map is a standard forest (vegetation) inventory map at a scale of 1:20,000. It incorporates elements of the digital base map sheet, showing features such as roads, trails, lakes, rivers and streams. The map's main feature is the forest stand (vegetation) polygons, each of which has a stand label consisting of stand number, species composition, site class, and the area in hectares. The full stand descriptions for all the stands also appear in a column on the left side of the map. It uses standard forest inventory and base map symbols. You can produce this map at any time.

iv. Composite map

This map is a typical forest (vegetation) composite map that can be produced for each management unit of the forest at a scale of 1:50,000. You have to specify the management unit before you can produce this map. The composite map has the same features as the forest resource inventory map (above) but with a stand label consisting of stand number, working group (dominant forest tree species), and site class. It uses standard forest inventory and base map symbols. You can produce this map at any time.

#### D. Planning-Allocation Maps

i. Harvest Allocation map

This map displays that part of the forest which is eligible for harvest and the stands which have been allocated for treatment

ii. Silviculture Allocation map

This map show you that part of the forest which is eligible for silviculture, and the stands which have been allocated for treatment.

#### **36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

No, not beyond what the user can do in terms of changing the properties and display of a particular theme as a result of a query or process such as Allocation.

#### **37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

ArcForest includes some built in forestry (growth and yield) business rules (calculations) tied to certain form fields and reports. Otherwise there are no built-in "knowledge-bases" per se that require calibration.

### User Support

#### **38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

ArcForest courses are held at the ESRI Canada Training Center in Toronto and are available to ArcForest end-users, ArcForest service provider companies and ESRI International Distributors. Standard per person training fees apply and a minimum enrollment is required for most courses.

- a. ArcForest Orientation and Training Kit (AOK) (including Tour Guide) - computer-based tutorial, self-paced, using sample data set with exercises;
- b. Intermediate ArcForest User Course - 3 days of instruction and exercises aimed at forestry and natural resource management staff using ArcForest beyond the in the AOK, AOK tutorial is a prerequisite;
- c. Programmer's Course - 4 days of instruction and hands on problem solving aimed at ArcForest systems analysts and ArcForest Accredited Consultants, covers adding in models, menus and other organization specific processes, prerequisites are AOK training, Arc/Info, AML, Unix, and RDBMS experience;
- d. Data Load Course - 2 days of instruction and hands-on experience on data loading, data conversion, and ArcForest data model, directory structures and data loading AMLs; aimed at ArcForest data/ systems analysts and ArcForest Accredited Consultants, prerequisites are Arc/Info, AML, Unix, and RDBMS experience;

- e. Training off-site - Training can be provided for ArcForest end-users, ArcForest service provider companies and ESRI International Distributors off-site on a per diem basis plus travel expenses.
- f. Training at Sir Sandford Fleming College in Lindsay, Ontario uses ArcForest in their natural resource management program. In conjunction with the School's "Canadian Natural Resource Training Center" initiative, ESRI Canada plans to accredit Sir Sandford Fleming as a classroom-workshop setting where there will be ample time to explore different case studies and exercise ArcForest's tools to their fullest extent. The College also offers accommodation and meal packages on-site and can provide transportation to and from Toronto (Pearson) International airport.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

A one year warranty is provided with the purchase of the product, beginning at the time of software installation. Annual maintenance fees for ArcForest are due at the end of the warranty period. Support for the ArcForest (Core) product is by ESRI Canada. ArcForest maintenance includes product upgrades for both ArcForest and the bundled-in Oracle, if applicable. ArcForest maintenance and support services include:

- Hot line telephone support between the hours of 9:00 a.m. and 5:00 p.m. (EST/EDT) Monday through Friday.
- Direct access to the ArcForest Electronic Mail Help via internet (arcforest@esri.com) twenty-four hours per day.
- Complete, documented upgrades of the Orientation & Training Kit (complete with tutorial database). This kit is an excellent training tool for new GIS staff and other personnel.
- New revisions and upgrades of ArcForest Standard License as they are released: including all necessary Oracle upgrades and associated documentation.

**40) Online support: Is there help available within the system?**

Yes, on-line support for each module and process is available.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

No, although, using Arc/Info-unix facilities a watch file can be invoked to track all ArcForest session processes. All ArcForest database update transactions are logged automatically as a part of the ArcForest Records Management Module functions. See also question 47.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

ArcForest's Tour Guide, with included data set and exercises, provides explanation, in a training context, of the rationale for certain processes in relation to resource management objectives. Some explanatory material is also included in the on-line documentation.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

ArcForest has a complete set of documentation organized into 3 Kits.

**A. ArcForest Orientation & Training Kit**

Tour Guide: a user-oriented tour of many of ArcForest's functions using a sample data set (300+p):

Unit 1: Basic Concepts, Unit 2: Exploration, Unit 3: MapComposer, Unit 4: SurfaceView, Unit 5: Planning, Unit 6: Record Management, Unit 7: Administration, Appendix A: Using a 3-button mouse, Appendix B: Function keys for Oracle forms, Appendix C: Logical expressions for Arc/Info, Appendix D: Logical expression for Oracle, Appendix E: Object editing rules (used in Update), Appendix F: How to user the digitizer, Appendix G: Eligibility reports and maps, Appendix H: Allocation reports and maps. Installation Guide: how to install ArcForest on your machine.

**B. ArcForest User's Kit:**

Reference Guide: alphabetical listing of all of the ArcForest's menu options and their use (also available as on-line help).

Tabular Data Management Guide: how to work with the ArcForest tabular database independent of ArcForest & Arc/Info. This document describes the tabular functions that can be run without the spatial

component of ArcForest including Query, Information display for primary ArcForest tables, Maintenance, Reports and System Administration.

#### C. ArcForest Programmer's Kit:

Programmer's Guide: how to add-in your own programs to ArcForest: Coding Standards, ARC Macro Language (AML) Program Standards, FORTRAN 77 Program Standards, C Program Standards, Directory Structure, How to Create a Sub-Module, How to Add Menu Options, How to Link RDBMS Forms, How to Maintain Help Documentation, How to Add a Model, Appendix A: AML Programs, Appendix B: Menu Programs, Appendix C: Shell Programs.

Data Load Guide: how to load data into ArcForest.

## Performance

### **44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

To run through a complete management planning session can take anywhere from 30 minutes to several hours. The variation depends on how well the user has thought through the scenarios in advance and their complexity. While some complex operations with large data sets can take 10-15 minutes to process, most delays result from the user not knowing exactly what criteria they want to use and what sequence of processing steps they want to follow. Naturally, there is also variation with the type of CPU and machine memory.

### **45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

Set-up time is minimal, once the data has been loaded into the ArcForest database. This is because a key focus of ArcForest is to organize your data sets so they can be worked easily and immediately. If modifications to the data were required some custom processes would need to be created.

## Computational Methods

### **46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

No models are included in ArcForest at this time.

### **47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

No. The next major release of ArcForest will have an enhanced data dictionary (meta data), possibly as an integral part of the data model itself. This enhancement could include information on the source, form and accuracy of the data.

### **48) Identify strengths of particular systems that are not included in the above list of attributes.**

In contrast to forecasting and assessment and other related analytical software applications, ArcForest's principle strength is in providing a sound and flexible infrastructure to organize, maintain and process much of the forest and related land information required to support strategic and operational planning. The system is designed to be used by non-technical users in an open, shared and distributed work environment.

# ARGIS

**1) System/tool Name: Title or acronym of tool.**

Active Response Geographic Information System

**2) Brief description: Short statement of purpose and functions.**

AR/GIS is a multi-user GIS tool used for place based negotiations. The user interface is designed for use by non-technical decision-makers. The tool is based on developing a linkage between an electronic meeting system and GIS. Meeting participants interact with laptop computers to assess the current status, develop decision criteria, and propose geographically based proposals/scenarios. Individual recommendations are collected via a local area network for group discussions, negotiations, & decisions. Decision rational for final recommendations are recorded automatically using the electronic meeting functionality.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

Brenda Faber, CIESIN, 1201 Oakridge Dr., Suite 100, Ft. Collins, CO 80525

Doug Fox, RM Station, 1201 Oakridge Dr., Suite 100, Ft. Collins, CO 80525  
970-282-5475, 970-282-5488

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

User needs to define analysis.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

No, it works on GIS coverages it is provided, they can be of any scale.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

No geographic limitations except user needs to have the data.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

They are explicitly treated to the extent that the user provides the data. The system assists the users to define elements then facilitates a group process to select among alternatives

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

The system does not do this, it allows display and manipulation by a group of the results of such analyses in geographic formats.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

As above the system facilitates working with analysis & model result

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

The system lends itself to a comparison of alternatives using a variety of tools for comparison. The user(s) needs to define the alternatives for consideration and the system provides assistance in how to do this with GIS coverages & data.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

Yes, that is what the system is all about.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

Yes, this is one of the primary purposes of the system, which includes group consensus tools.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

Not explicit but the system facilitates comparisons both visual and analytic between alternatives.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

Not at present, but it is MS Windows based.

The system links electronic meeting software with the GIS ArcView.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies?**

Yes

**Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

Nothing is explicitly built into the system, it is a fully functioning ArcView GIS however.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

Yes, this is the fundamental purpose of the system.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

No

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

No, this is up to the user.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

As a fully functioning version of ArcView it can do what ever the user wishes that is available in ArcView. Generally it simply displays different GIS data coverages & builds new ones based on user(s) determined algorithms

## **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partial operation, operational)?**

Operational prototypes have been built for (1) the Arapaho Roosevelt Forest Planning process; (2) a land purchase decision by a city government. Others are in progress

**21) Current users: List existing successful applications and users.**

Arapaho-Roosevelt NF, City of Scottsdale Az., ESRI, IBM.



**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify language and operating systems.)**

It is a MS-Windows based tool much of which is written in Avenue the ArcView APL. We operate it on a LAN of PC laptops.

**Specify languages and operating system.**

The system is based on Vantana Inc GroupSystems V for Windows & ESRI's ArcView. Earlier systems were developed with limited functionality in MS-DOS with IDRISI gis.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

PC 486, 16 Meg RAM, 1 gig Disk.

**24) Software requirements and costs: What is the operating system?**

MS Windows

**Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

ArcView is on the order of \$1,000 perseat (but available under 615). Vantana's GSV is approximately \$20,000 for a full 25 person license. Hardware is 20-25 laptops configured as above, approximately \$60,000.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

On the order of \$5,000 per year.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Development is pretty well completed. Customization on the order of \$20-100,000 per application is needed but this estimate really depends on the specifics of the project.

**27) Target user: Who will actually run the system?**

We generally expect to run the system. It is possible that a user might wish to purchase & use her own which would require considerable training.

**Who needs to be involved in setting up data? List the organizations and levels applicable.**

Primarily the data needs are GIS coverages so the GIS capability of the organization would need to be involved. Second the decision-maker needs to work with us to develop the formats applications.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

NOT specific at all.

## **Inputs/Outputs**

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

ArcView data inputs and outputs

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

Yes, the system facilitates users working with the data.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

GIS coverages are needed in ArcView compatible formats.

**32) Incomplete data: Will the system run with incomplete data?**

No, it needs good data coverages.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)?**

Yes

**Does it run directly or import and export data to/from corporate data bases?**

Don't know, never tried.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Maps, charts, graphs

**35) Report generation: Describe the types of reports generated.**

Standard formats from GSV include a report capability but this needs to be customized for users.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

NO, needs the decision-makers as a group to define their values & decision criteria, then is weighs proposals against them.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

No

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

We have not tried to do this other than to train our staff on the use of the system. It is not easy or short term.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

We envision working with users in application, tailoring the system to their applications. Perhaps in the future this might be an option.

**40) Online support: Is there help available within the system?**

Yes, the two software packages that are it's basis ArcView & GSV both support good user help.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

Yes

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

NO, unless you develop them as a group.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

Excellent for the components, poor for AR/GIS itself.

## Performance

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

This is developed as an online meeting support tool so analysis etc. are pretty quick. Of course this depends on the complexity/size of the GIS coverages being accessed.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

Generally weeks to months, with good ArcView data more like a week to two weeks.

## Computational Methods

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

User specifies.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

None

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

This is a unique tool, there is nothing like it yet available. At a recent National Science Foundation sponsored workshop to investigate group GIS, AR/GIS was acknowledged as the only operational prototype available of the subject of the Workshop. It is a research tool and requires our involvement in applications at the present time.

# CRBSUM

## 1) System/tool Name: Title or acronym of tool.

CRBSUM (a Columbia River Basin SUccession Model)

## 2) Brief description: Short statement of purpose and functions.

The Columbia River Basin SUccession Model (CRBSUM) simulates broad-scale landscape vegetation changes as a consequence of various land management policies. It was designed to compare the effects of alternative management strategies on vegetation dynamics. This model can be used to: 1) predict future landscape conditions as a result of alternative management plans, 2) investigate the interaction of disturbance processes with vegetation dynamics, 3) map the distribution of disturbances on the simulation landscape, 4) spatially describe the composition and structure of future landscapes.

CRBSUM is a spatially-explicit, deterministic model with stochastic properties that simulates changes in vegetation cover types and structural stages on landscapes over long time periods using probabilities. Successional dynamics are modeled using a multiple pathway approach where successional community types, called Succession Classes, are linked along pathways converging to a stable community type called a Potential Vegetation Type (PVT). Each Succession Class is described by a cover type and structural stage. Disturbance is stochastically simulated as a change in cover type or structural stage using probabilities that reflect a possible management action or natural event. The model does not simulate a fixed schedule of disturbances (e.g., treatment intervals) but rather models the occurrence and location of a particular disturbance using probabilities.

The successional pathways comprise the heart of the CRBSUM simulation engine. There is a successional pathway for each Potential Vegetation Type (PVT) recognized on the simulation landscape. A PVT is the endpoint of the successional pathway and identifies a biophysical setting that supports a unique and stable climax plant community (e.g., habitat types, plant associations). Therefore, boundaries of PVT's do NOT change with time (i.e., static). Any disturbance can be included in a successional pathway, but the scale of the disturbance should match the scale of application. All cover types and structural stages on the initial landscape, no matter how they are defined, should be present in the successional pathways.

CRBSUM is adaptable to many land planning situations because all parameters and initial values are specified as inputs to the model. Application of the model to different land areas and different land management policies require only minor modification of the input parameters. Moreover, a PC-based tool called VDDT (Vegetation Dynamics Development Tool) can be used to develop, test and refine the succession and disturbance parameters, and then the modified values can be downloaded directly into CRBSUM. CRBSUM was developed primarily for mid (100-200 meter pixel) and coarse (1 km pixel) scale applications. CRBSUM can be used for fine scale applications but the companion model DISCONT must be used in conjunction with CRBSUM to properly simulate disturbance processes that "spread" across a landscape such as fire.

CRBSUM is a computer program developed in the C language for a SUN workstation with the UNIX operating system. This program is actually a collection of programs integrated into the LOKI simulation system. LOKI is a simulation environment that allows the linkages of various computer models and databases in time and space. Output from CRBSUM can be imported directly into Geographical Information Systems (GIS) for further analysis and display.

CRBSUM was used to simulate coarse scale landscape changes in the Interior Columbia River Basin (ICRB) as a result of four management scenarios. CRBSUM results have an inherent 1-5% variability because of the stochastic structure of the model. Sensitivity analysis results suggest moderate changes in disturbance probabilities (25% increase) will only slightly affect simulation results. Accuracy of CRBSUM results depends on the quality of model input parameters. Future versions of CRBSUM will rectify conceptual and computational limitations with model design. This involves linking contagion with disturbance processes, including more complex probability distributions and improving results presentation and format.

The LOKI software system is used to spatially simulate succession with CRBSUM. LOKI is an event-driven, model development platform that allows the execution of submodels that operate at different

resolutions of time and space. The LOKI software also has map query and modification routines. All input and output maps used in the CRBSUM modeling effort were created or accessed using LOKI routines.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

Bob Keane, IFSL, P.O. Box 8089, Missoula, MT 59807,  
406-329-4846, FAX 406-329-4877, DG: B.KEANE:S22L01A

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

Does NOT handle NEPA issues directly, must answer the issues in the context of model output.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

CRBSUM has a mid- to coarse scale application because simulation is accomplished at a pixel level. This means all disturbances and probabilities must be simulated pixel-by-pixel. A 100 meter to 1000 meter pixel width is about right for most disturbances except for fire and some insect/disease epidemics. In those cases the model DISCONT can be executed with CRBSUM to simulate contagion properties.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

CRBSUM will work in any area on earth as long as the model is properly parameterized. It was initially developed for the Interior Columbia River Basin ecosystems.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

Biophysical elements are implicit in the stratification of the landscape as required by CRBSUM. The coarse scale landscape must be divided into static units called Potential Vegetation Types which are explicitly dependent on site conditions such as climate, soils, topography and so on.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

The model outputs maps and tables of cover type, structural stage, succession age and disturbance distributions. The user is responsible for the assessment of these conditions with respect to management issues.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

CRBSUM predicts the composition and structure of a landscape into the near (1-10 years) and distant (1000+) future. CRBSUM does not compute, simulate or estimate a desired future condition. CRBSUM outputs can be compared with DFC's statistically or qualitatively to determine similarity.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

CRBSUM was especially designed to compare the consequences of alternative management policies on landscape structure and composition. There is a timber volume output scheme that allows the spatial and tabular presentation of timber amounts generated by simulation year. The model does not perform the comparison of alternatives, this is left up to the user (as it should be).

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

Many other models can be linked to the Loki software system to execute other analysis simultaneously with CRBSUM simulation. As a result the user can link or piggy-back other models that explicitly display and test alternatives and trade-offs.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

NO, consensus-building methodology is not included.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

No, there are no direct feedback functions implemented in the model other than the direct modification of model parameters. Again, other programs can be added into this Loki application to accomplish this task.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

YES, CRBSUM can be executed on one machine and display output on a host of other machines using the Loki software. Also, Loki allows the concurrent execution of other models across machines.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

NO, landscape metrics and spatial analysis is not a part of CRBSUM and the outputs would not be conducive to a spatial analysis.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

YES, CRBSUM displays and analyzes alternatives spatially.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

NO, all CRBSUM simulations are at the same spatial (variable) and temporal (annual) scale. Interactions across scales are scaled up to the scale of application and treated (or not treated) accordingly.

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

NO, the system does not recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

The data can be as precise and accurate to scale as the user desires. Input data and parameters can be aggregated up or developed for that scale.

## **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partial operation, operational)?**

CRBSUM is currently available for use on various projects but the model execution is NOT user-friendly and/or easy to operate. The user must know something about Loki and all about CRBSUM to properly operate the system. There is no "pretty" GUI in which the user can quickly and efficiently initialize, parameterize and operate the model.

**21) Current users: List existing successful applications and users.**

CRBSUM has been used extensively in the ICRB scientific assessment and EIS project. It is slated to be used for a variety of mid- to coarse scale applications across various National Forests.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

CRBSUM and Loki can be transported to other systems. They are currently running on SUN and IBM workstations under a UNIX operating system and they were programmed in ANSI C. Installation may be somewhat difficult because both programs are still in their "infancy".

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

CRBSUM needs at least 64 MB RAM and about 300-500 MB disk. It only runs under a UNIX platform.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

CRBSUM needs Loki for successful operation. It only runs under a UNIX system.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

NONE.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

The only expense will be the development of the input data layers needed by the model. These layers can sometimes be costly.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

CRBSUM should be run by a high-end GIS user with extensive knowledge of successional processes. CRBSUM simulations should be centralized and done by accomplished GIS people who have run the model before.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

The system can be run on any platform anywhere so it need not have US governmental agency involvement.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Six ASCII data files are used as input to CRBSUM: 1) Driver File, 2) Simulation File, 3) Succession File, 4) Scenario File, 5) Structural Stage Initiation File, and 6) Volume File. Data contained in these files are stored into memory at the beginning of a CRBSUM execution. The first file is called the Driver File and it is a metafile that contains the filenames used for all input and output files. The Driver filename is specified on the command line used to initiate execution of the CRBSUM program. The remaining five input files are specified within the Driver File.

The Simulation File contains information on user-defined specifics of the simulation such as the number of years to simulate, pixel size, initialization values and so on. Information on successional dynamics of all PVT's is contained in the Succession File. Probabilities comprising a management scenario is entered in the Scenario File. Lastly, information on the distribution of structural stages by PVT and cover types is contained in the Structural Stage Initiation File. This file is used to initialize the starting Structural Stage Map if unavailable (see Map Initialization section).

The Succession and Scenario ASCII files are structured hierarchically with finer stratifications nested within a coarse scale framework. All information for a stratum is entered on one record (i.e., line) in the file. The level of stratification is usually indicated by the degree of indentation in the file. Data are entered on each file record in free format. Therefore, it is only critical that the information be entered in the correct order and be separated by at least one blank. An unfortunate "side-effect" of free-formatting is that alphanumeric names cannot contain blanks because the name-part after the blank will be interpreted as separate field and the program will return an error. So, another character should be substituted for the blank in two-word names (e.g., use Whitebark-Pine or WhitebarkPine for Whitebark Pine). Alphanumeric names should be shorter than 64 characters. More than one space can be used to delimit fields so record information can be aligned by columns for ease of data entry and correction. The Identification Numbers (i.e., ID numbers) specified in each file must be consistent across and within files. For instance, if the Dry Douglas-fir PVT in the Succession File is assigned an ID number of 12, then the Dry Douglas-fir PVT in the Scenario File must also have an ID of 12.

**Simulation File** — The first line in the Succession File is a title line used for file documentation and is skipped by CRBSUM. This title line is present on all CRBSUM input files. The remaining lines describe the specifications of a CRBSUM simulation. Only one number is entered on each line. Number of years to simulate is on the first line. The second line is the date at which simulation is to commence. The scale of application is specified next. Mid and fine scale specifications require the linkage of the disturbance contagion model DISCONT to CRBSUM in the Loki application. Specified in the next lines are attributes that describe extent of other input files. The number of phases included in the Scenario File, followed by the number of Management Regions in the Scenario File, the number of PVT's in the Succession File, and the number of cover types in the Initial Structural Stage File are entered on successive lines. These numbers serve as error-checks on the data entered in the corresponding files.

The next set of lines specifies the options of the initialization and output routines. The structural stage initialization method is specified on the 10th line (see Dynamic Initialization section) and succession age initialization procedure is entered on the 11th line (see Age Initialization section). Types of tabular output results is specified on the next line where a full summary includes all types of output discussed in the Output section. A short summary creates a statistic file that describes only PVT/Cover type/Structural Stage yearly distributions by Management Region; an action summary is a statistics file containing only the extent of disturbances in the simulation area; and a full summary without tables does not have summary tables of simulation results. The output interval is specified on the next line. CRBSUM will print output to statistics files at the specified output interval (years). Harvest volume output is next with either volumes or codes printed. Harvest codes are used if no volume equation exist and user wishes to compute volumes at a later date.

The last set of lines identify the disturbances to plot on the Loki maps. There is an output Loki map for each of five broad disturbance categories: 1) Fire, 2) Insect and Disease, 3) Harvest, 4) Grazing and 5) Generic Disturbance. Line 15 contains the number of actions to monitor for each map. A number of disturbance ID's, up to the maximum specified on line 15, are specified on the next set of lines. These disturbances are mapped as one entity on one Loki map. Disturbance type ID's are specified by the 4 digit action code entered in groups of 10 (maximum per line) for the next set of lines. The name of the map is skipped by CRBSUM. The model maps the occurrence of these disturbances as a group and does not distinguish between codes for a given map.

**Succession File** — The first line in the Succession File is also a title line used for file identification and is skipped by CRBSUM. The next line contains information on the first PVT. This line contains the PVT Identification Number (ID), PVT name (without spaces, i.e., concatenated) and the number of Succession Classes associated with this PVT. The next line concerns the first Succession Class of this PVT. Succession Class records contain the Succession Class ID, structural stage ID, cover type ID, beginning successional year of the stage (BegYear field), successional year marking the end of this stage (EndYear field), Succession Class ID to use when succession age is greater than the ending year (NextClass field), initial succession age to use for the Initial Age Map (InitAge field, see Landscape Initialization section) and number of disturbances that can affect this PVT/Succession Class combination.

The next set of lines contain information concerning disturbance effects on the Succession Class. These disturbance lines contain the disturbance ID, disturbance name, the Succession Class ID the pixel reverts to if this disturbance occurs (GoToClass field), the succession age of the resultant class (AgeSet field) and the age increment (AgeIncrement field) estimate. These disturbance ages are discussed in detail in the



Disturbance Simulation section. The next line after the set of disturbance information records is the next Succession Class for this PVT and succeeding that is the set of disturbances pertaining to this successional stage, and so on. Each Succession Class need not have a full list of disturbances especially if a particular disturbance does not make sense (e.g., selection cut in sagebrush grassland). However, each PVT in this file needs information on the entire set of successional stages. It is important that data in this file match corresponding data in the Scenario File. If the Scenario File specifies a treatment for a PVT/successional stage combination that is not represented in the Succession File, the program will return an error and terminate.

**Scenario File** — This file contains the set of disturbance probabilities stratified by Phase, Management Region, PVT, Succession Class that constitutes a Management Scenario. The hierarchical structure of this file has information on the scenario implementation time interval (i.e., Phases) at the highest level, followed by Management Region information. These two levels allow the user to design scenarios for a variety of time intervals and geographic areas. Nested under regional information are the disturbance probabilities stratified by LandUnits which are a PVT/Succession Class combination treated as a single level in the Scenario File for simplicity, unlike the structure of the previous Succession File. Under the LandUnit level are the set of actions or disturbances that this PVT/Succession Class can experience.

The first record in the file contains data for the first phase of the scenario. The phase ID is entered first on the record, followed by the phase name, the year that the phase commences (PhaseStart field), the year the phase ends (PhaseEnd field), and the number of geographic regions included in this phase implementation. Geographical regional information is entered on the next record with region ID entered first, region name entered next, then number of LandUnits involved in the management action. LandUnit information is entered on the next line with PVT ID number entered first, then the PVT name, the Succession Class number, and lastly, the number of possible disturbances involved at this level.

The next set of records detail the implementation of disturbances or management actions. The disturbance record format has disturbance ID entered first, then disturbance name, and lastly, the probability that this pixel will experience that disturbance. This probability can be viewed as the probability of any piece of ground (i.e., pixel) experiencing a particular perturbation given the specified phase and the pixel's Management Region, PVT, and Succession Class. The NO-ACTION management action is assumed by default so it need not be specified. For example, if a particular PVT-Succession Class combination is not entered in the Scenario File, but occurs on the landscape, then the pixels in this combination would only experience successional development as specified in the Succession File. Again, it is important that the specified disturbances for a LandUnit (i.e., PVT/successional stage combination) are represented in the Succession File.

**Structural Stage Initiation File** — This file is simply a cross-reference table detailing the distribution of structural stages by PVT and cover type. It is only needed if there is NOT a raster map of initial structural stage conditions. This file is structured with structural stages nested under PVT and cover type at the coarsest level. This file need not be created for every CRBSUM application. The first line of this file contains information on the first cover type with the ID number first, followed by the cover type name and the number of PVT's that occur in this cover type. The next line has information on the first PVT where the first cover type might occur. The PVT ID, name and number of structural stages found in this cover type and PVT combination are then entered on this record in that order. This next set of records contains information on all structural stages that can occur in this PVT/cover type. The structural stage ID is entered first on the record followed by the name of the stage and the percent occurrence of this combination. The percent occurrence represents the relative frequency (in percent) of a successional stage in an cover type within a given PVT. These percentages must add to 100.0 across all structural stages within any PVT/cover type combination.

**Volume File** — A Volume File is needed if harvest volume estimations are to be written to output files and to maps. This file contains volume equation parameters for each PVT, Succession Class and harvest disturbance code combination entered in the Succession File. The volume equation predicts timber volume (m<sup>3</sup>), based on: the volume (m<sup>3</sup>) at the beginning of a Succession Class, the slope of the line (m<sup>3</sup> yr<sup>-1</sup>), a volume reduction factor to adjust for harvest technique, and the transition time to the next Succession Class in years (Stage and others 1995). Equation parameters for the ICRB CRBSUM simulation effort were quantified by Stage and others (1995) using multiple runs of the FVS model.

**Input Maps** — CRBSUM needs at least three maps to start simulation. These maps are imported to Loki from GIS software prior to CRBSUM execution (Bevins and Andrews 1994, USA CERL 1990). The first map is the Management Region Map (Loki map Mgtregion) that delineates those areas that will receive different sets of disturbance probabilities. CRBSUM uses the Management Region Map to define the effective simulation area. All areas having a zero in the Management Region Map will not be simulated. All other input Maps having zero values where Management Region Map has values greater than, zero are assumed to be in error. The second map is a raster layer of PVT's called the PVT Map (Loki map Pvt). The third map is a raster layer of initial cover types (Initial Cover Type Map, Loki map Lcc).

Also needed for a CRBSUM simulation are the Initial Structural Stage Map (Loki map Stg) and Initial Succession Age Map (Loki map AgeInit). These maps can either be created independently by the user or stochastically generated by the CRBSUM model during the dynamic initialization process. Methods of age and structural stage initialization are specified in the Simulation File and discussed next. The combination of PVT, cover type and structural stage for any pixel will always key to a Succession Class, which along with PVT will reference all information in the Succession and Scenario Files.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

YES of course...

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

CRBSUM requires the user to enter their own successional and management data.

**32) Incomplete data: Will the system run with incomplete data?**

NO, but the user may decide to repeat fields in order to get the program to run with a limited data set.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

CRBSUM can use corporate data if the data input algorithms are reprogrammed which is a minimal task.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Loki allows the addition of any series of visualization programs that present CRBSUM outputs. I ran GRASS, GeoExplorer and AxMap to generate real-time map graphics for landscape change.

**35) Report generation: Describe the types of reports generated.**

CRBSUM Output File Formats

DATA FILE: LANDSCAPE.STAT

- 1 YEAR 5 Integer Simulation year
- 2 MREG 6 Integer Management region ID
- 3 PVT 6 Integer Potential vegetation type ID
- 4 CLASS 11 Integer Succession Class ID
- 5 STAGE 11 Integer Structural stage ID
- 6 COVER 11 Integer Cover type ID
- 7 AREA 11.2 Real Area of coverage in this type (km<sup>2</sup>)

DATA FILE: ACTION.STAT

- 1 YEAR 5 Integer Simulation year
- 2 MREG 6 Integer Management region ID
- 3 PVT 6 Integer Potential vegetation type ID
- 4 CLASS 11 Integer Succession Class ID
- 5 STAGE 11 Integer Structural stage ID
- 6 COVER 11 Integer Cover type ID
- 7 ACTION 11 Integer Management Action ID
- 8 AREA 11.2 Real Area of coverage in this type (km<sup>2</sup>)

DATA FILE: HARVEST.STAT (with Volume Equations)

- 1 YEAR 5 Integer Simulation year
- 2 MREG 6 Integer Management region ID
- 3 PVT 6 Integer Potential vegetation type ID
- 4 CLASS 11 Integer Succession Class ID
- 5 STAGE 11 Integer Structural stage ID
- 6 COVER 11 Integer Cover type ID
- 7 HARVEST 11 Integer Harvest Management Action ID
- 8 AREA 11.2 Real Area of coverage in this type (km<sup>2</sup>)
- 9 VOLUME 11.2 Real Volume of wood harvested (m<sup>3</sup> ha<sup>-1</sup>)

DATA FILE: HARVEST.STAT (without Volume Equations)

- 1 YEAR 5 Integer Simulation year
- 2 MREG 6 Integer Management region ID
- 3 PVT 6 Integer Potential vegetation type ID
- 4 CLASS 11 Integer Succession Class ID
- 5 STAGE 11 Integer Structural stage ID
- 6 COVER 11 Integer Cover type ID
- 7 HARVEST 11 Integer Harvest Management Action ID
- 8 TRANTIME 11 Integer Transition time to next class (yrs)
- 9 AREA 11.2 Real Area of coverage in this type (km<sup>2</sup>)

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

NO, the system does not interpret results.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

The user can elect to use any of the successional and scenario defaults developed by the ICRB scientific assessment, or the user can modify these defaults, or the user can use his/her own values.

## User Support

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

There are no training sessions for the model. We teach people how to use the model using real data in real world situations.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

NO, must contact author.

**40) Online support: Is there help available within the system?**

NO, must contact author.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

NO, user must track origin of all data. Program does have a log file that records the details of any simulation run.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

NO.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

There is only one published document that details the intimacies of CRBSUM:

Keane, Robert E., James P. Menakis, Donald Long, Wendel J. Hann and Collin Bevins. 1996.

## Performance

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

It takes about 36-50 hours to simulate a 1000x1000 pixel landscape depending on the number of disturbances to be modeled.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

It can take up to 2-3 months to create the input stream for CRBSUM if the user is familiar with the model.

## Computational Methods

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

Deterministic successional dynamics model with stochastic properties.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

Does the system explicitly deal with (1) accuracy of estimates (NO), (2) the ways errors are propagated through time and space (NO), (3) uncertainty and risk (NO), or (4) sensitivity analysis (YES)? A sensitivity and validation of the models was done for a portion of the ICRB and the results are in the above publication.

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

CRBSUM is robust and flexible. The user can implement any disturbance in any ecosystem and simulate the outcomes.

# EMDS

**1) System/tool Name: Title or acronym of tool.**

EMDS

**2) Brief description: Short statement of purpose and functions.**

EMDS provides knowledge-based decision support for watershed analyses. Knowledge bases in EMDS represent knowledge of how analysis topics relate to ecosystem functions, processes, and data. Given a set of selected topics, the system determines data requirements, retrieves existing data, and evaluates the state of the selected topics. Because EMDS uses symbolic reasoning, topic states can be partially evaluated with incomplete data. EMDS also uses its knowledge of relations to prioritize the value of missing data. The knowledge base system is linked to GIS; states of topics, ecosystem function and state, and various views of missing data can all be displayed on maps.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

Keith M. Reynolds, PNW Research Station  
Corvallis Forestry Sciences Lab  
3200 SW Jefferson Way  
Corvallis, OR 97331  
Phone: 541-750-7434

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

No

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

Prototype is designed for watershed analysis. The system can easily be adapted to other scales.

**6) Geographic region applicability: In what locales will it work? Is it limited without major modification?**

The inference engine that processes knowledge bases is generic and will work anywhere. The knowledge bases are meta-data that generally require adaptation beyond the Oregon Coast Range province.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

Knowledge bases for current prototype deal explicitly with biophysical elements. Current knowledge bases cover anadromous fish, effects of roads and structures on streams, and surface waters. A knowledge base for terrestrial wildlife has been designed but not fully implemented. A knowledge base (KB) for vegetation is planned for completion in FY96. New knowledge bases for social and economic elements are easily integrated.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

Yes, symbolic reasoning.

**9) Predict future conditions: Does the system predict future conditions and evaluate against Desired Future Conditions (DFC's)? What methods are available?**

Predictive capability is planned for FY96, funding permitting. Prediction for DFC's uses a combination of simulation and symbolic reasoning.

- 10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Alternatives are evaluated separately.

- 11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

GIS is used to display outcomes.

- 12) Consensus building capability: Is explicit consensus-building methodology included?**

This is planned for FY96, funding permitting.

- 13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

No, but this is a feature that could easily be added in the future.

- 14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

No, but this capability is planned.

## **Spatial Issues**

- 15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

All adjacency info is displayable, some is analyzed, for example, the wildlife KB will link to the habscaes model which analyzes patch suitability. The planned vegetation KB will link to a simulator with explicit spatial interactions.

- 16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

Yes.

- 17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

No, but this is planned. The intent is that results of watershed analyses will feed into province analyses, using distributed database technology.

- 18) Scale-appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

Yes.

- 19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

Predominately transformation.

## **Basic Development/Status**

- 20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operation, fully operational)?**

Prototype 2 completed in October 1995.

Prototype 3 due to be completed in January 1996.

Prototype 4 (which includes vegetation and wildlife) could be completed by September 1996 if there is funding.

**21) Current users: List existing successful applications and users**

Not yet in use.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

Operating system is MS-DOS, using Microsoft Windows (3.1 OR 95). ArcView interface can operate on either PC or UNIX. KB interface (Written in KnowledgePro) would need to be converted to UNIX.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

Minimum CPU is 486, 50 MHZ. Minimum RAM is 32 MB. Disk storage for program is about 12 MB (ArcView plus KB interface). Disk storage for data is highly variable. (Data for one watershed is about 2-10 MB).

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

Operating system is MS-DOS with Windows 3.1 OR Windows 95. No compilers needed. All libraries used have runtime-free distribution. Cost of ArcView is \$1200. EMDS system is free.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

Not yet determined.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

FY96:

Prototype 3: funds already obligated.

Prototype 4: \$250K (vegetation and wildlife KBs, and extension of operability to local area network.)

Prototype 5: \$150K (Automated report generation)

FY97:

Prototype 6: \$200K (Province scale analysis)

Prototype 7: \$150K (Extension of operability to wide area network)

Beginning with prototype 4, development of Kbs for social and economic topics could also be added for about \$100k per year.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Watershed and province analysis team members. Local GIS Staff can set up data catalogue used by system. Applicable to all organizations (federal, state, and private). Levels (for Forest Service for example) are district, forest, and perhaps region.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

Application is not Forest Service specific.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Currently uses Dbase data format. Prototype 4 will use any ODBC-compliant DBF format.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis.**

Not automatically, however data input requirements are specified in the knowledge bases which are metadata and can be modified by the user.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Both

**32) Incomplete data: Will the system run with incomplete data?**

Yes

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Will Directly use Oracle data as of prototype 4.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Bar charts, tables, maps.

**35) Report generation: Describe the types of reports generated.**

Reports will summarize what was done when and by whom. User will be able to add most system outputs into a report.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

Yes. Most output is to maps. Various ArcView functions are available.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

Some knowledge bases will require user modification for adaptation to new provinces not included in prototype development. Others will be more or less universal.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

Training is expected to require no more than 1 day. They do not currently exist (system still in development). On-line help system will make self-training very feasible.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

To be determined.

**40) Online support: Is there help available within the system?**

Yes.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

Yes.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

Yes.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

Not yet available.



## Performance

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

5-10 minutes.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

Clean data: 1 day. Dirty data: not applicable.

## Computational Methods

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

Symbolic reasoning, fuzzy logic, simulation, deterministic (wildlife habitat model), stochastic (vegetation model).

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

Rather than accuracy or risk, KBs report truth values of assertions associated with analysis topics. Truth values indicate to what degree the evidence favors or refutes the assertion being made. Uncertain effects of data inputs on states and processes are handled with fuzzy logic. The vegetation simulator will deal with state-transition probabilities between seral stages, and cell-to-cell transmission of contagion. Users will be able to modify parameters through dialog setup windows to perform sensitivity analyses. Specific methods for treatment of error propagation, uncertainty, and risk have yet to be determined, but will be treated explicitly so that users can evaluate their influence.

**48) Identify particular system strengths that are not included in the above list of attributes.**

None.

# FireBGC

## 1) System/tool Name: Title or acronym of tool.

Fire-BGC — a Fire and BioGeoChemical process model

## 2) Brief description: Short statement of purpose and functions.

A fire and vegetation mechanistic model called FIRE-BGC (a FIRE BioGeoChemical succession model) simulates long-term stand dynamics on coniferous forest landscapes of the Northern Rocky Mountains. This model can be used to investigate cumulative fire effects for various fire scenarios including prescribed burning, fire exclusion, and historical fire regimes. FIRE-BGC is an individual tree model created by merging the gap-phase, process-based model FIRESUM with the mechanistic ecosystem biogeochemical model FOREST-BGC. It has mixed spatial and temporal resolution in the simulation architecture. Ecological processes that act at a landscape level, such as fire and seed dispersal, are simulated annually from stand and topographic information contained in spatial data layers. Stand-level processes such as tree establishment, growth, and mortality, organic matter accumulation and decomposition, and undergrowth plant dynamics are simulated both daily and annually on a simulation plot that represents the stand. Tree growth is mechanistically modeled using the ecosystem process approach of FOREST-BGC where carbon compounds are produced daily by forest canopy photosynthesis. Respiration and transpiration are also calculated daily. The net carbon gain allocated to tree stems at the end of the year generates a corresponding diameter and height growth. Fire-BGC is continually being tested with field and other model data. It was designed to be applied to different forested landscapes with minimal modification of the computer code.

Fire-BGC is the union of two ecosystem process models developed from very different approaches. The gap-replacement model FIRESUM (Keane et al., 1989, Keane et al., 1990a, Keane et al., 1990b) was merged with the mechanistic biogeochemical simulation model FOREST-BGC (Running and Coughlan 1988, Running and Gower 1991) to predict changes in species composition in response to various ecosystem processes over long time periods. The mechanistic approach of FOREST-BGC improved the level of detail needed to understand those ecosystem processes that govern successional dynamics. FIRESUM's comprehensive simulation of forest dynamics in multi-species stands, and its integration of fire interactions with ecosystem components allow Fire-BGC to simulate changes in species composition and abundance as a consequence of multiple disturbances over long time periods.

Creation of Fire-BGC used the mechanistic design of FOREST-BGC as the framework and engine for ecosystem simulation. Then important FIRESUM algorithms were added to the framework to simulate multi-species forest succession. These FIRESUM routines were then refined to utilize detailed information generated from the mechanistic FOREST-BGC routines. Finally, this modeling framework was implemented in a spatial context recognizing the spatial distribution of these processes across a simulation area (Busing 1991, Urban et al., 1991). This allowed detailed simulation of ecosystem processes that act across several spatial scales (Bonan and Shugart 1989).

Fire-BGC models the flow of carbon, nitrogen and water across various ecosystem components to calculate individual tree growth. Carbon is fixed by tree leaves (i.e., needles) via photosynthesis using solar radiation and precipitation inputs, and then distributed to leaves, stems and roots of individual trees. A portion of the leaves, stem and roots are lost each year and accumulate on the forest floor in the litter, duff and soil. These forest floor compartments lose carbon through decomposition. Nitrogen is cycled through the system from the available nitrogen pool. Carbon and nitrogen are allocated to each tree's stem, roots and leaves at year's end. Stem carbon allocation is used to calculate diameter and height growth.

Fire-BGC has a mixed time resolution built into the simulation design. Primary canopy processes of interception, evaporation, transpiration, photosynthesis and respiration are simulated at a daily time step. Secondary canopy processes of carbon and nitrogen allocation are accomplished at a yearly time step. Tree mortality, regeneration and growth are also computed annually. Seed dispersal and fires are simulated at near-decadal time steps.

Two spatial scales are explicitly implemented in a Fire-BGC application. Ecosystem processes that occur at the landscape level, such as seed dispersal and fire, are modeled in a spatial domain using raster data layers. These landscape processes are simulated by external programs directly linked to Fire-BGC. Stand-level processes, such as tree growth and regeneration, are modeled independent of the spatial environment. Dynamic databases provide the linkage between landscape and stand-level process simulation.

There are five hierarchical levels of organization implemented into Fire-BGC design. The coarsest level is the simulation landscape and it is defined as a large expanse of land (greater than 10,000 hectares) delineated by the natural boundaries that control the major properties of that ecosystem including climate, vegetation and disturbance. This landscape is divided into units called sites that have similar topography, soils, weather and potential vegetation. Boundaries of each site are static and do not change in a Fire-BGC simulation. The third level of organization is the stand. Each site is composed of a number of stands that are different in vegetation composition and structure. By definition, stand boundaries cannot extend past site boundaries. Stand boundaries are not stationary in Fire-BGC since processes of succession, fire and pathogens serve to alter stand boundaries within a site. The fourth organization level is the species level. Any number of species can inhabit a stand. Many modeled processes such as canopy dynamics and tree regeneration are performed at the species level. The finest level of organization is the tree level. Each tree within a simulation plot is explicitly modeled in the Fire-BGC architecture. Many attributes of each tree, such as leaf carbon, diameter and height, are recognized in Fire-BGC. However, these trees are not spatially defined in the model.

Fire-BGC was written in the C programming language using a modular approach based on organizational levels implemented in model design (Keane et al., 1995). Relationships and parameters are shared across modules as objects or functions. The program was developed on a SUN Sparc Model 10 workstation and accesses several software packages and databases during execution.

The LOKI modeling architecture is used to link and schedule execution of the Fire-BGC program and associated models SEEDER (seed dispersal model), MAPMAKER (an ecological mapping routine), FIRESTART (a fire occurrence simulator) and FARSITE (fire behavior model) at the appropriate time intervals (Bevins et al., 1994, Bevins and Andrews 1994). LOKI also provides Fire-BGC and sub-models routines to query, modify and create digital landscape maps during simulation. The GRASS spatial GIS package is used for organizing, displaying and analyzing raster files created by LOKI (USA CERL 1990). Linkage of these models to simulate long-term ecosystem dynamics for this study is called the Fire-BGC application.

**IMPORTANT:** Fire-BGC was developed as a research tool. There are no plans to modify the model so it can be used to solve day-to-day issues at National Forest districts. The model is too complicated and complex to be used as a managerial tool without the proper scientist involvement.

### **3) Developer/Contact: Name, Organizational unit, address, phone.**

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Intermountain Research Station, Intermountain Fire Sciences Laboratory  
Missoula, MT 59807, Phone (406) 329-4846, FAX: (406) 329-4877  
email: DG: B.KEANE:S22L01A

## **Scope and Capabilities**

### **4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

This model was not built to answer NEPA issues. The results of the model can be used to evaluate NEPA demands but the model does not explicit provide results in a NEPA-ready format.

### **5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

Fire-BGC was designed for mid- to fine scale applications. Spatial resolutions include 30-150 meter pixel sizes or 1:24,000 to 1:100,000 map scales. It is a landscape model that simulates vegetation dynamics across stands upward in scale.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

Ideally, Fire-BGC can work in any forested setting but it was especially designed for use in the Rocky Mountains. It is possible to parameterize the model for any forested ecosystem.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

Biophysical elements are explicitly simulated in Fire-BGC using a mechanistic approach. For example, the "site" is described in Fire-BGC by a fire regime, weather stream, fuel characteristics, undergrowth attributes and other processes. No social or economic analysis are included.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

YES, Fire-BGC assesses current conditions using a mechanistic approach.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

YES, Fire-BGC can be used to predict future conditions of ecosystems and their processes. However, Fire-BGC does NOT evaluate against DFC's. The future conditions can be near-term (10-100 years) or long term (1000+ years).

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

YES, Fire-BGC can be used to compare management alternatives and their effect on ecosystem process, function and state. Currently, Fire-BGC only allows alternative fire treatments but timber harvesting will be added at a later date. Social and economic outcomes are NOT included.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

YES, there are functions that offer novel ways to display model results for public participation. NO tradeoff analysis is included.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

NO, consensus-building methodology is not included.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

YES, there are feedback functions in Fire-BGC that allow users to understand why a particular alternative incurs such change. Fire-BGC has a varied model output that allows real-time and post-processing evaluation of these feedbacks.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

YES, Fire-BGC can be run on several systems at once using the LOKI software system.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

YES, there are several spatial analyses that are included in a Fire-BGC simulation. Seed dispersal and fire behavior are just a few of the processes that act at a spatial scale. Fire-BGC results can be used to determine landscape metrics and for corridor analysis, fragmentation, and habitat relationships.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

YES, Fire-BGC simulates and displays model results spatially.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

YEW BET, Fire-BGC has a nested spatial and temporal simulation scale structure to account for all important processes that occur on the landscape. These cross-scale interactions are modeled explicitly or indirectly. Fire-BGC links many across-scale interactions in the simulation of ecosystem processes. Weather provides a good example of process linkages that progress downward in organizational scale. Weather year is selected for the entire landscape. Daily weather attributes values for that year are selected from site-specific climate files. These weather data are used to compute photosynthesis and respiration at the stand level for that site. Important weather events such as frosts and drought are computed at the stand-level for the simulation of species dynamics. Carbon fixed through photosynthesis at the stand-level is allocated to the trees based on the distribution of radiation in forest canopy, which is computed from the site weather file and the stand's canopy structure.

Fire-BGC also accounts for interactions that occur upwards in organizational scale. At the end of the simulation year, Fire-BGC sums all carbon and nitrogen tree compartments for a new estimate of stand carbon and nitrogen components. The abundance of a stand's seed crop trees by species is written to dynamic data files for use in the landscape application of the seed dispersal model. Simulated fires burn a stand's forest floor compartments (i.e., fuels) but use site level weather files and landscape topography for computation of fire spread and intensity.

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

NO, the system does not recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales. It is currently being modified to include prescriptive treatments and scheduling. The model does not provide advice.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

The output data can be summarized across scales or be printed out for the scale in questions.

## **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Fire-BGC is currently operational.

**21) Current users: List existing successful applications and users.**

Fire-BGC has been used to investigate the effects of global climate warming on Glacier National Park vegetation and fire regimes. It is also being used to investigate landscape composition and structure under various fire regimes in the Bob Marshall Wilderness Complex. Fire-BGC has not been used in any management-oriented applications as yet.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

Fire-BGC was programmed in ANSI C so it should be transportable to many systems. However, it was also programmed to run with Loki which may have some software application problems.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

It would take about 64MB memory and 1 GB disk for a Fire-BGC application considering the input and output maps required.

- 24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

Fire-BGC runs under UNIX OS with the public domain software package Loki. It has been compiled under Lucid C with the associated libraries.

- 25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

NONE.

- 26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Fire-BGC will be undergoing constant change and modification.

- 27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Fire-BGC will only be run by those people who know the model. It is anticipated that management will come to research and ask that Fire-BGC be applied to their special project. Research will parameterize, initialize and execute the model and pass those results back to management.

- 28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

YES, the system can be run outside USDA Forest Service.

## **Inputs/Outputs**

- 29) Import/Export functions: List data formats that can be imported or exported, including reports.**

FIRE-BGC contains many ways to generate simulation output. The FIRE-BGC sub-model produces a variety of daily and annual stand and tree table files. FIRE-BGC also allows the user to specify a variety of stand characteristics to print in the dynamic Stand Attribute file. The MAPMAKER sub-model then reads this Stand Attribute file every year and creates and displays spatial data layers of those characteristics that can then be input into a Geographic Information System such as GRASS. Stand characteristics printed to the Stand Attribute file are selected by the user in the Driver file. These characteristics include net primary productivity (NPP), water use efficiency (WUE), standing crop (SC), and dominance type based on species basal area (DT).

FIRE-BGC provides many avenues for the printing of intermediate, non-spatial results during program execution. Model calculations can be printed to a variety of ASCII files depending on the temporal and organization scale. These ASCII files can then be imported into statistical and graphics software packages for analysis and display. The model was programmed to allow the printout of additional variables with little or no modification of the program.

- 30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

NO, the system will not let user define and output variables. However, Fire-BGC is capable of outputting up to 1000 variables at daily, yearly or decadal time steps.

- 31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Fire-BGC needs to be re-parameterized for each new application area. Some variables will need little or no modification but overall, the model would need new data.

- 32) Incomplete data: Will the system run with incomplete data?**

NO, the model will not run with incomplete data.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Fire-BGC does NOT use corporate data structures (Arc/Info and Oracle) as yet. It is currently being modified to input and output to/from some major GIS and databases systems.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

The model outputs maps and tables. The user needs to import these data results into GIS or graphics packages to display data.

**35) Report generation: Describe the types of reports generated.**

Reports are generated at the daily, annual and decadal time steps for any attribute at any of the organizational scales implemented in the model. For example, stand basal area can be output yearly whereas stand photosynthesis can be output daily.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

NO, the system does not interpret outputs.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

The inputs are parameters to process relationships. No coefficients or knowledge bases are fixed into system.

## User Support

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

The is no training for this model.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

Yes from the author.

**40) Online support: Is there help available within the system?**

NA

**41) Self-documentation: Does the system keep an activity log and data lineage?**

YES, there is an extensive storage of data lineage.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

NO, the system does not provide references and explanations.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

A paper describing all relationships in the model is being published early in 1996. This paper is extensive and detailed and provides sufficient documentation to aid users. However, there is no manual for executing the model. The following are some publications describing the model:

Keane, R.E., P. Morgan and S.W. Running. 1995. FIRE-BGC: A mechanistic ecological process model for simulating fire succession on coniferous forest landscapes. In press as INT Research Paper. 231 pages.

Keane, R.E., K. Ryan and S.W. Running. 1995. Simulating the effect of fires on northern Rocky Mountain landscapes using the ecological process model FIRE-BGC. Tree Physiology (in press to be published in March 96).

Keane, R.E., W.J. Hann. 1995. Simulation of vegetation dynamics after fire at multiple temporal and spatial scales — A summary of current efforts. In press in Proceedings of a Interior Fire Council

Meeting "Fire Management Under Fire — Adapting to Change", Nov. 1-3, 1994, Coeur d'Alene, ID, USA.

Keane, R.E., K. Ryan, and S.W. Running. 1995. Simulating the effects of fire and climate change on northern Rocky Mountain landscapes using the ecological process model FIRE-BGC. USDA Forest Service General Technical Report RM-262, pages 39-47.

## **Performance**

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

It takes about 10-12 hours to run a typical fire alternative in Fire-BGC on a SUN workstation.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

It takes about 3 months to sufficiently parameterize Fire-BGC and get ready for alternative comparisons.

## **Computational Methods**

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

Mechanistic simulation model with deterministic and stochastic properties.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

There is no accuracy evaluation or treatment of error propagation. A sensitivity analysis is currently being conducted but it will take about a year.

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

The wide range of outputs and comprehensive simulation of ecosystem processes are the strengths.



# FVS (Forest Vegetation Simulator)

## 1) System/Tool Name: Title or acronym of tool

Forest Vegetation Simulator (FVS)

a.k.a. The Prognosis Model for Stand Development

(Answers given below refer to the combined set of models including the Parallel Processing Extension (PPE) and various other extensions to the base model that represent shrubs, insects, diseases, and/or fire-fuels, behavior, and effects.)

## 2) Brief description: Short statement of purpose and functions.

Starting with inventories of existing primary vegetation, the model provides simulated estimates of the future states of primary vegetation. The model can represent a large number of alternative management activities. In the growth and yield literature, the model is termed an "Individual tree, distant-independent growth model."

## 3) Developer/Contact: Name, Organizational unit, address, phone.

Albert R. Stage, William R. Wykoff, Nicholas L. Crookston, David A. Hamilton, Robert A. Monserud, Melinda Moeur, INT-4154.

Contact: Nick Crookston, Intermountain Research Station, 1221 South Main, Moscow, ID 83843 (208) 883-2317.

Ralph Johnson, Gary Dixon, and others, Forest Mgmt Service Center, Ft. Collins, CO.

Contact: Gary Dixon, Forest Management Service Center, 3825 E. Mulberry, Ft. Collins, CO 80524 (970) 498-1814.

Bov Eav, Matt Thompson, Methods Application Group, Ft Collins, CO.

Contact: Bov Eav, MAG, 3825 E. Mulberry, Ft. Collins, CO 80524 (970) 498-1784.

## Scope and Capabilities

### 4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.

User must define.

### 5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?

FVS (without extensions) operates at the stand level. The PPE is designed to expand the scope to a landscape (up to about 1,000 to 2,000 stands). The ability to use the system a larger scales would require the use of statistical inferencing procedures.

### 6) Geographic region applicability: In what locales will it work? Is it limited without major modification?

There are geographic "variants" of the base model that cover most of the forested land in the United States.

### 7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)

The system only relates to the biophysical elements. Representation of economic issues is supported when the model is used with other tools, but not directly. Forest stands, structure, function, and composition are all represented.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

The model starts with a report of current conditions as they are represented by sample inventory data of the vegetation. It does not "assess" these conditions (except that it uses the current conditions to self calibrate).

**9) Predict future conditions: Does the system predict future conditions and evaluate against Desired Future Conditions (DFC's)? What methods are available?**

It predicts future conditions and can provide evaluations of the difference between simulated conditions and DFC's if the DFC's are described to the model by the user.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

With respect to managing the primary vegetation, the PPE has methods which assist users in simulating large numbers of alternative management regimes.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

There are no functions directly related to aiding a public participation process. See question 10.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

No.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

No, other than the fact that the model provides predictions which can be compared to monitoring data.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

No.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

It can analyze a few spatial adjacencies constraints. In general, its capabilities are limited. Currently, the system can represent a maximum clear-cut size constraint by limiting the selection of stands for clear cutting if clear cutting them would create a contiguous opening greater than a user-specified size. The definition of what is meant by a clear-cut can be tuned by the user. The system has the potential to represent some other spatial relationships.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

Only when the output is passed to other systems (which is commonly done).

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

Levels:

1. Tree.
2. Stand (a collection of trees, usually a sample based inventory).
3. Landscape (a collection of stands).

Interactions between the stand and tree level are explicitly treated using several statistical methods. This is one of the model's strong points. Interactions between stands and landscapes are treated by the

PPE. The flow of information from the stand to the landscape level is accomplished by making simple summations of stand conditions to calculate landscape averages and/or totals. The PPE can compute a "target" number of acres in a specific "state" (where state could be in the "state of providing cover", for example), and/or a target harvest volume, and then select stands for management as needed to achieve the overall target. This is an example of information flow from the landscape back to the stand level.

**18) Scale-appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

It implicitly recognizes these differences, but it does not provide advice. It provides data that represent the outcomes of implementing specific schedules of management actions, AND/OR outcomes of following one or more different management policies.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

From the tree to stand level, data are transformed as well as aggregated. From the stand to landscape levels data are aggregated and disaggregated.

## **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Fully operational (in general).

**21) Current users: List existing successful applications and users**

Heavy use by Forest level foresters in preparation of forest plans. Heavy use by Regional and Zone level forest pest managers in preparation of forest insect and disease assessments. Some use by District level foresters in preparation of project level assessments. Used in several habitat assessments including those done in the southwest, California, and the Columbia River Basin.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

System is written in Fortran-77. It runs on PC's, workstations, and several other computer systems.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

Under PC-DOS, you need 2.5 megs memory and a FPU. Disk storage, etc., depends on the size of the problem. Workstations and larger systems generally have the necessary system resources.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

No extra software needed.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

No license requirements.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

INT-4154 spends about \$100,000/yr (including staff costs), FM Service center spends about \$300,000/yr (including staff costs), and MAG spends about 100,000/yr. These numbers have not been verified.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

District silviculturists and foresters.

Forest silviculturists and planners.  
Regional office timber management and pest management specialists.  
It is also used by the BLM, the BIA, several state governments, and British Columbia.  
Industry: counterparts of the same levels.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

The system is agency independent.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Flat files.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis.**

The system has a limited ability to accept user-defined input variables (specified in a system-defined format) and include them in the analysis. The system does allow users to define output variables that are functions of internal system variables.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Both.

**32) Incomplete data: Will the system run with incomplete data?**

Yes.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Yes. It runs on imported data from the corporate data base, or on other data directly supplied by the user.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

None (except for output tables). The system relies on follow-on processes for visualization.

**35) Report generation: Describe the types of reports generated.**

Stand tables, species and size composition, volume and densities all over time. Management activity schedules.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

No.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

There are defaults and capabilities for users to adjust coefficients. The system will automatically calibrate to some of the input data, but this is not required.

## User Support

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

Training is available. Sessions are 1 week. Self-training is feasible.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

Yes. Problem determination and direct support is available.

**40) Online support: Is there help available within the system?**

No.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

It outputs an activity log, but it does not produce direct information on data lineage.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

No.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

The documentation is rather complete, but sometimes it is hard to acquire. A new user interface is being built that will include online documentation.

## **Performance**

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

For one stand: 5 to 10 seconds.

For a large landscape, over 300 years: several hours.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

Clean data: 5 mins to 15 mins for a large collection of stands. Raw, un-edited data: 2 hours per stand or more.

## **Computational Methods**

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

Deterministic, stochastic, simulation, and knowledge-based methods are all used.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

1. Yes in a limited way. It outputs statistics that indicate if the input data are unique with respect to what the model normally expects.
2. Yes, the growth models explicitly represent how variation in stand conditions over time and space influence growth. And, the model tends to dampen measurement errors and errors of estimation so that they don't cause the system to produce abnormal predictions. And, NO, the model does not explicitly deal with all kinds of possible errors and their potential implications. Sometimes, estimates of very poor quality are produced by the model without warning the user.
3. Yes, the model explicitly represents some forms of uncertainty and risk (such as the risk of having a bark beetle infestation) and No, it does not represent all forms.
4. No, not as a built in feature. (But external sensitivity analysis have been done are still underway.)

**48) Identify particular system strengths that are not included in the above list of attributes.**

The system has been around quite a while. It is rather well understood and quite stable. It does the tasks it was primarily designed to do quite well.

# GypsES

**1) System/Tool Name: Title or acronym of tool**

GypsES: the Gypsy Moth Decision Support System

**2) Brief description: Short statement of purpose and functions**

GypsES is a tool for organizing and evaluating information to be used in gypsy moth control, suppression, prevention, or eradication efforts. It is built around visual display of information through the GRASS GIS and several simulation models.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

Dan Twardus  
USDA Forest Service  
180 Canfield Street  
Morgantown, WV 26505-3101  
304-285-1545

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

NEPA issues are not handled explicitly. Analyses and problems are defined by the user.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

The system is designed for use at the landscape scale primarily, on areas ranging from very local to county-wide projects. Data acquisition and storage are the primary limiting factors at regional scales.

**6) Geographic region applicability: In what locales will it work? Is it limited without major modification?**

GypsES can be implemented anywhere if data exist. It is most applicable where gypsy moths are found, and some functions are dependent on forest types, but only minor modifications are necessary to facilitate use elsewhere. Additional modifications can make the program useful for evaluating management activities other than gypsy moth-related.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

Social elements are treated explicitly only through the use of maps of land use, housing density, etc. Economics of treatment alternatives are analyzable. Biophysical elements used explicitly include forest composition and structure, topographic variables, and others.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

Yes. Knowledge-based analyses are used to evaluate gypsy moth populations and likelihoods of defoliation. Various descriptive statistics are available to analyze forest composition, gypsy moth infestations, and other variables.

**9) Predict future conditions: Does the system predict future conditions and evaluate against Desired Future Conditions (DFC's)? What methods are available?**

Simulation models within GypsES predict future forest growth and mortality under different infestation and treatment alternatives. Future populations of gypsy moths are also simulated.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Up to four different alternatives can be displayed and analyzed simultaneously, including all variables within the system. Which elements are displayed is entirely under the user's control.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

Yes. Alternatives can be displayed simultaneously, and recalculation and redisplay of different alternatives or different variables is quick.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

No.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

The system is capable of maintaining historical and sequential data, but no explicit functions require a user to learn.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

Data can be shared across locations, but the system is presently designed to operate independently.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

Yes. GypsES is spatial at heart, because it is built around the GRASS system of GIS. Display of maps and other graphics are an integral part of the system. Analysis of adjacencies (landownerships, spray drift, and others) are included.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

Yes.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

No. It displays and analyzes areas in question from individual pixels (30-m squares) to the full area for the location (county or larger) equally.

**18) Scale-appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

GypsES deals directly with prescriptive and allocative decisions at fairly local scales and does not provide advice on broad policy.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

Data are aggregated as appropriate.

## Basic Development/Status

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operation, fully operational)?**

The system is fully operational in both suppression and eradication formats, and is undergoing continued enhancements.

**21) Current users: List existing successful applications and users**

Prince William County Gypsy Moth Program  
Arkansas Department of Agriculture Plant Protection Division

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

GypsES is written in C and operates in X-Windows under Unix. Implementations exist for Intel, DEC, and Sun platforms. Porting to IBM/AIX for Forest Service applications is in progress.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

Minimum requirements are a 486 with 32 Mb of RAM and 1 Gb storage.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

The operating system is Unix and X-Windows. The GypsES software is public domain. Users must maintain a Unix operating system.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

There is no charge beyond the operating system license.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Continued development is at risk for lack of funding, which is estimated at \$200,000 per year through FY 1998.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Specialists at the local level (county, Forest, District, e.g.) run the system. Specialists in computer data bases or programming are usually involved in setting up data and establishing a system at a new location.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

The system is currently in use both inside and outside the Forest Service.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

The system uses a combination of data formats, but primarily GRASS data sets. Import and export from and to all standard GIS packages is available. Import routines for data from Oracle tables have also been developed.



**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis.**

Data entry is user-friendly. Importation of other, non-standard data sets must be accomplished through development of translation programs.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Both.

**32) Incomplete data: Will the system run with incomplete data?**

Yes, although some data are required.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Yes, through import and export functions.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Maps are the heart of the program, with graphs, tables, and other charts available.

**35) Report generation: Describe the types of reports generated.**

Reports are available in map and tabular form, plus narrative text.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

(No answer provided.)

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

Most coefficients needed by the system have defaults but are user-modifiable as desired.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

Some self-training is feasible. Training sessions currently run 3 days. Familiarity with Unix is helpful.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

Hot-line telephone support is available. Site visits also can be arranged if needed.

**40) Online support: Is there help available within the system?**

Yes, there is an extensive help system within the program.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

Yes.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

Yes.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

The manual is extensive and complete from the perspective of providing explanations of how the system works and what the different menu options and buttons do. The manual is readable, but only by those persons inclined to open a manual. The online help system is almost as complete. Internal documentation is also extensive.

## Performance

- 44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

Analyses take from a few moments to under an hour, depending on the size and complexity of the location and the analyses.

- 45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

Data set up for a new location may take a few days for a small area with good initial data to several weeks if data need modification and cleanup.

## Computational Methods

- 46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

Simulation modeling and knowledge-based reasoning are the primary modeling techniques in use.

- 47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

Sensitivity analysis can be done explicitly with several functions within GypsES or implicitly by the user's manipulation of input variables. Accuracy and uncertainty are recognized as potential variables of interest but have not yet been addressed directly.

- 48) Identify particular system strengths that are not included in the above list of attributes.**

There are real people actually using GypsES to help with their real world problems.

# IMPLAN

## 1) System/tool Name: Title or acronym of tool:

System/Tool Name: IMPLAN

## 2) Brief description: Short statement of purpose and functions.

IMPLAN (IMPact analysis for PLANning) is software and an extensive economic database which assists the analyst in tracking the regional economic impacts of project, program, and policy decisions. Using the widely utilized technique of "input-output" analysis, IMPLAN builds profiles of regional economic linkages under different scenarios posed by the analyst.

## 3) Developer/Contact: Name, Organizational unit, address, phone.

USDA Forest Service users contact:

Greg Alward and Susan Winter

USDA Forest Service - Ecosystem Management

3825 E. Mulberry Ave.

Fort Collins CO 80524 Phone: (970) 498-1861, 498-1759

Other Organizations/Users contact:

Minnesota Implan Group

5830 Hytrail Ave. No.

Lake Elmo, MN 55042-9542 Phone: (612)779-6638

## Scope and Capabilities

### 4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.

IMPLAN is well suited to the calculation of the economic impact of alternatives, though NEPA analysis *per se* is not "canned" in the program. The most common uses of IMPLAN in NEPA analysis has been the prediction of effects on employment and income of alternatives. A recent extension to IMPLAN (natural capital accounts) was used to link explicitly economic activity with a wide range of environmental variables such as pollution, population growth, wildlife habitat loss, and others (for more information, contact the Forest Service office above).

### 5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?

The smallest unit in the IMPLAN database is the county. Data are available from the Minnesota Implan Group by ZIP code which can be on an even smaller scale. The system is flexible enough, however, that an analyst could use other data to build a model for a smaller area yet, though that would be a mammoth task. County and state data files can be combined to define any geographic region up to the national level.

### 6) Geographic region applicability: In what areas will it work? Is it limited without major modification?

IMPLAN data are specific to every county in the U.S. allowing tailored models to be built for any geographic region in the nation. For other countries, the IMPLAN software can use outside databases, so models could be built for any region in the world given appropriate information.

### 7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)

The IMPLAN system is a classic tool for regional economic impact analysis. IMPLAN models explicitly illustrate the inter-linkages between economic sectors in an economy, and estimate the ripple effects throughout the economy of changes in the characteristics of one or more sectors in the economy. Economic attributes which can be tracked are:

Production: Output in each sector, amount of production destined for final consumption vs. for inputs to other sector production, output per employee, sectors with strong ties to local economy (i.e.; purchases

of inputs locally, sales of output locally), exports and imports of inputs, exports and imports of output, pattern of purchases by high, medium, and low income consumers, purchases and sales of production by federal and local governments, purchases of production for inventory and capital formation, diversity of economy's economic base, level of dependency of economy on largest sectors for economic growth and stability.

**Employment:** Total employment in the economy, employment in each economic sector, identification of labor intensive vs. capital intensive sectors.

**Income:** Value of wages and benefits received by employees in each sector, productivity of labor, income of sole proprietorships, indirect business taxes (sales, excise, and value added taxes), property income (dividend, interest, and rental).

In the current version of IMPLAN, explicit linkages to consumption and use of natural resources, particularly non-market resources, are few. However, instructions are available from the US Forest Service (address above) that allow a straightforward linkage to be built between environmental impacts and economic activity.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

IMPLAN provides a extensive and detailed description of the current economic structure and dynamics of a regional economy.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

IMPLAN provides equally detailed projections of the future condition and dynamics of a regional economy.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

IMPLAN was developed specifically for economic impact analysis of natural resource management alternatives. Using expenditure data IMPLAN can gauge the regional economic impact of alternative policies, programs, and projects. For example, IMPLAN has been used to estimate the regional economic impact of alternative timber harvest levels, grazing fee levels, recreation types and levels, alternative spotted owl set-aside plans, Forest Service (or any other organization) funding levels, levels of PILT and 15% fund payments to counties, project sizes, land use options, levels of funding for the arts, the economic impact of earthquakes, the impact of establishing new industries in an area, among others. IMPLAN is used extensively for regional impact analysis both by the Forest Service and other federal and local government agencies, as well as by university researchers and consultants.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

???

**12) Consensus building capability: Is explicit consensus-building methodology included?**

No explicit consensus-building methodology is included aside from the ability of IMPLAN to compare an unlimited number of alternatives.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

IMPLAN allows the analyst to edit the databases to reflect ground truthed data, hypothetical data, data forecasts, or other data derived from local studies or sources.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

Though no specific links are designed into the IMPLAN system, all data, intermediate computations, input output tables, and impact analysis results are available in database form. This allows for any number of queries to be made on the data and any format of reports to be generated, facilitating the creation of data sets which are compatible with other software packages.

## Spatial Issues

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

IMPLAN is a geographical application in the sense that data are related to either individual or contiguous blocks of counties, states, and/or the US. Obviously, these political boundaries will not always match closely any particular ecological unit. If desired, however, with some effort any data set can be edited to match economic characteristics with ecological unit boundaries. There is no internalized mapping capability in IMPLAN, but data files can be exported which can be used by mapping and spatial applications.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

Given the restrictions described in #15 above, analysis at different spatial scales is accomplished with IMPLAN by using multiple models. Analysis is displayed in tabular form with geographic references. IMPLAN does not map results or alternatives.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

IMPLAN builds a picture of a regional economy based on geographic size of the region, among other things. In this way, economic interactions change based on scale and the complexity of the economy being modeled. Multiple models can be built for multiple scales. The natural capital accounts extension to IMPLAN described in #4, above, can be used to link different ecological scales with different economic scales. These linkages are not internalized in IMPLAN, however.

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

The analyst must distinguish between prescriptive, allocative, and policy decisions in the design of regional models. There is no internalized mechanism in IMPLAN to make this distinction.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

All IMPLAN models reflect the scale of economy being modeled. Interactions between economic players can vary significantly, depending on the size and complexity of the model economy, particularly in the case of trade relationships. Some types of data, such as production and employment, are simply aggregated and disaggregated.

## Basic Development/Status

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Current status: IMPLAN has been a fully functional system since 1979. Micro IMPLAN for DOS is available free from the USDA Forest Service or for a small fee from the Minnesota IMPLAN Group (MIG). See #3 for addresses. Two different IMPLAN for Windows versions are currently under development. Greg Alward of the US Forest Service will have a no-cost version ready for beta release in 6/96. A commercial package is being developed by the Minnesota Implan Group for release in 6/96.

IMPLAN databases are the property of Minnesota IMPLAN Group. Data are available free of charge for Forest Service employees under site license. All other users must purchase the data from MIG. Data availability and price information is available from MIG (see #3).

**21) Current users: List existing successful applications and users.**

- Economic impact assessment of such things as recreation and tourism, or the construction, expansion, or closing of manufacturing facilities.

- Natural resource policy analysis. For example, ecosystem management, fee or lease impacts, or energy, water, or land conservation policies.
- Economic strategic planning, i.e. community and rural development, business retention or expansion, competitive position of local firms, industrial targeting, import substitution, and export expansion.
- Business incubators and venture financing, i.e. business location, business volatility.
- Government expenditure analyses, i.e. impact and targeting of state aid to local governments, military procurements, and the impact of transfer payments such as taxes and social programs.
- Regional economic studies such as identification of the diversity and dependency of the economic base, industrial structure and linkages, regional trade analyses, and regional gross product measurements.
- Extended applications using IMPLAN plus other analytical tools; energy input-output analysis, multi-regional I-O models, transportation system models, fiscal impact models, occupational supply and demand models, population and employment and income forecasting, and computable general equilibrium models.

Current IMPLAN users include over ten federal agencies, as well as a large number of state and local agencies, universities, and private companies and consultants.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

IMPLAN currently runs on any IBM compatible computer under DOS 3.0 or higher. As discussed in #20, above, Windows compatible versions will soon be released.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

The DOS version of IMPLAN requires an IBM compatible computer, 8088 or higher CPU, math coprocessor, and 537K of free RAM. The program itself occupies 7MB of disk space. Each data file occupies 47K of disk space. The total amount of space occupied by data files will depend on how many counties and or states are going to be used by the analyst.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

Program availability is discussed in #20 above. Sources of the program and data are listed in #3, above. A price list for the data is available from the Minnesota IMPLAN group. Prices vary according to the size and complexity of the county or state being ordered.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

Support is offered free of charge by the Forest Service for other Forest Service employees. Other users are offered support for a fee from the Minnesota IMPLAN Group.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

None anticipated.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Anyone interested in the regional economic effects of projects, policies, and events.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

This is a completely flexible system which can be used with ease outside of applications specific to the Forest Service.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

The DOS version imports and exports ASCII files. The Windows version uses database files and so can import and export a wide variety of formats with the use of database programs.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

Users can submit any amount of original data. Formats are very restrictive with the DOS version. A great deal more flexibility is built into the Windows version, though there are still certain limits.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Both.

**32) Incomplete data: Will the system run with incomplete data?**

No, IMPLAN needs a complete data set.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

The DOS version must import/export ASCII files. The Windows version can interface with corporate databases as long as they are in forms that can be read by database programs.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Information is displayed in tabular form within IMPLAN. Graphical display of the data is accomplished with outside programs.

**35) Report generation: Describe the types of reports generated.**

An extremely long list of reports can be generated by IMPLAN. In addition, with the Windows version, the generation of user-defined reports is quite easy. The database structure of the Windows version facilitates unique queries that fit the user's requirements.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

IMPLAN provides little output interpretation aside from the way information is displayed in reports.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

In the DOS version, there are many fixed coefficients. In the Windows version, the user can choose between these "canned" coefficients and ones provided by the user.

## User Support

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

Training for Forest Service users is available from the Ecosystem Management unit listed in #3 above. All other users must contract with MIG for training. Training sessions usually last 3 days. Self training is possible, but is quite difficult due to the unfortunate lack of self-training materials.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

Forest Service users can call the office listed in #3 above. All others are given a certain amount of telephone support by MIG, provided upon purchase of software or data.

**40) Online support: Is there help available within the system?**

MIG has a World Wide Web page with a wealth of information on IMPLAN and email.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

IMPLAN keeps a log of when models are built and/or changed.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

Other than an analysis guide (available from MIG) and an online help system, there are no references or explanations provided.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

The User's Guide (available from the Forest Service or MIG) and the online help system are adequate, but a serious gap in documentation has been the lack of an analysis guide to help the user formulate questions and models correctly. That problem has now been rectified by the publication of an analysis guide by MIG (see address in #3, above).

## **Performance**

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

Execution time varies dramatically based on the hardware used and the complexity of the model economy. The DOS version is faster than the Windows version. For example, with a 486 running under DOS, a simple economy would take less than 5 minutes to model and run an alternative on. A more complex area, such as the United States, could take 15-20 minutes. The Windows version could take 10 minutes to 2 hours under the same example.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

There is no way to predict how long it would take to set up. Analyses with IMPLAN can run the gamut from extremely simple, requiring only a few minutes of input, to complex, requiring days or weeks of preparation. The time required depends on the complexity of the question to be analyzed, and the amount of data editing that would be required.

## **Computational Methods**

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

IMPLAN simultaneously solves a set of linear equations with matrix inversion.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

IMPLAN does not explicitly deal with any of these issues.

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

IMPLAN is one of the few resources available to analysts which looks at the big picture - the regional economic impacts of policies and management alternatives. Given that most economic tools available for resource management analysis focus at the project level, IMPLAN can be an important tool for developing an overview of the economic impacts of management decisions.



# INFORMS

## 1) SyStem/tool Name: Title or acronym of tool.

INFORMS (Integrated Forest Resource Management System)

## 2) Brief description: Short statement of purpose and functions.

INFORMS is a DSS which supports landscape and project-level planning by integrating needed planning tools into a user-friendly interface. Easy and logical user access is provided to data management, GIS, modeling, and knowledge base tools. The INFORMS framework allows relatively easy custom configuration to accommodate the variety of tools, planning methods, and databases used across USDA-FS Ranger Districts nationwide. The functions supported by INFORMS include project definition, scoping, pre-alternative analysis, alternative creation, post-alternative analysis, and document preparation. The design is based on extensive analysis of user requirements using CASE methodology.

The responses to this questionnaire are largely gleaned from the experiences of current users and the INFORMS Requirements Analysis Document. For more information and background on INFORMS, refer to this document. This document contains detailed evaluations of existing operational prototypes, copies of published papers, and various products generated using Oracle's CASE Tools such as an Entity Relationship Diagram, a Function Hierarchy, and related CASE reports.

## 3) Developer/Contact: Name, Organizational unit, address, phone.

Sponsors/Developers::

Forest Health Technology Enterprise Team  
Forest Health Protection  
3825 E. Mulberry Street  
Fort Collins, CO 80524  
Contact: Steve Williams or Patrice Janiga (970-498-1500)

Region 8 Forest Health Protection  
Alexandria Field Office  
2500 Shreveport Highway  
Pineville, LA 71360  
Contact: Forrest Oliveria (318-473-7286)

STARR Lab, Department of Range Mgmt and Ecology  
Texas A&M University  
College Station, TX 77843  
Contact: Dr. Douglas Loh (409-845-1551)

## Scope and Capabilities

### 4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.

INFORMS has been and is being used in both NEPA and NFMA related analysis.

User sites have specific analytical methods and tools they use for various analytical problems. INFORMS is thus adapted by users at each site to give access to those tools and to facilitate management of input data and output data so that the analysis is easier. The tools themselves are used to handle issues explicitly if they are that type of tool. Some users have used the knowledge base component to build specific issue related rulebases. The Arkansas site has over 2 dozen such rulebases. Other sites use research-produced simulation models and complex database queries to explicitly address NEPA issues. Most sites will use a combination of all of these tools. These rulebases, models, and queries are all available to a user via INFORMS, and access and use is consistent with the typical NEPA process. In addition, as new tools and techniques evolve, it is relatively easy to reconfigure INFORMS to support those tools.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

A project can be defined at virtually any scale. INFORMS supports definition of a project area boundary and resultant extraction of desired spatial and attribute data into project files/tables. Tools, queries, etc. are then executed against project area data as desired. Existing users have specific rulebases, queries, and models which they use for different types of analyses. For instance, on large project areas such as a watershed, certain rulebases may be used in the analyses but these rulebases may not be appropriate on small projects. On the 615 version of INFORMS, users will be able to choose a project type when defining a new project. Project types defined to date include NEPA analysis, NFMA analysis, and insect and disease analysis, but future users may define new types to meet their needs. This project type will then be used by the system to suggest which tools, in the suite of available tools, to use for the analyses. This project type/tool selection function is configurable for each site.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

INFORMS will function and support planning needs in all district and other USDA-FS units nationwide without modification. INFORMS is built on commercial software available with the 615 platform and will function on any 615 platform. To that extent, non-USDA-FS entities can use INFORMS if they have a unix platform with ArcInfo and Oracle (several outside entities such as the Nature Conservancy have expressed interest in INFORMS).

Perhaps the most important strength of INFORMS is flexibility. The underlying design of INFORMS allows it to work easily with resource data stored in virtually any Oracle database. Special effort was made to design INFORMS to work with any of the variety of resource databases used in the USDA-FS. The design is based on extensive analysis of user needs and databases across at least 3 USDA-FS regions. CASE products generated from this analysis, primarily the Entity Relationship diagram were used to build INFORMS. Design plans have been cross-checked with representatives of IS&T to ensure consistency with USDA-FS database policies and standards.

Given that planning methods, tools, and resource databases vary widely across the USDA-FS, INFORMS is remarkably useable since it can be easily configured to support these methods, tools, and databases.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

These questions really pertain to the specific models or analytical tools integrated within INFORMS. Because these models and tools vary from site to site there is no easy answer. In general, most sites use appropriate models and tools via INFORMS to support analysis, and some of these treat structure, function, and composition explicitly and some treat them implicitly. The rulebases tend to be more implicit whereas many simulation models treat these explicitly. The models targeted for integration into INFORMS (in addition to those integrated by and for user sites) include all those sponsored by Forest Health Protection staffs such as vegetation-insect-disease models and their reports.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

Yes, and in a very user friendly environment. Beyond simple queries of both spatial and attribute data, users use complex queries, ArcInfo AMLs, rulebases, and various models to perform these assessments. On the 615 version of INFORMS analytical outputs are easily massaged into useful reports using the mapping and graphing capabilities of ArcView. In addition, sponsors of INFORMS also sponsor development of Data Visualization software which will eventually be available as a tool within INFORMS.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

Yes, through the integration of various simulation and successional models within INFORMS. Long range plans for INFORMS include a capability to compare alternatives and model outputs against system stored issues and constraints. The data structure already exists to support this function but the routines to actually perform this function are not as yet implemented.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Alternative creation is a key function of INFORMS, and users of previous prototypes have been particularly impressed with this function. Alternative parameters are available through the INFORMS data structure such that models can more easily be configured to simultaneously evaluate these alternatives. Choice selection utilities are not currently part of the system. Commercial decision/choice selection packages are being evaluated for potential integration with data structures associated with the "alternative" outcomes.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

Yes and no. Explicit functions are available to quickly create and display color coded maps based on model, rulebase, or query outputs. However, the basic outputs that are used to create these maps must be generated by a tool the user has chosen to integrate in INFORMS. The coordination of this project with a data visualization project (mentioned previously) will in the long run produce a powerful public participation tool.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

Not to the extent that commercial software designed specifically for this purpose does (electronic "voting", etc.). However, current users have expressed great satisfaction in the ability to use INFORMS to facilitate team meetings, address issues, and reach consensus. This satisfaction is due in part to the ease of use of the system and in part to the ability to quickly use tools to generate analytical outputs that address a variety of issues. Team members have raised concerns and issues at meetings, and users have been able to immediately access the set of INFORMS integrated tools, select the proper tool, and then generate output which addresses the issue at hand. The fact that it is so easy to integrate many different tools means that users, over time, generally have a tool available to address issues raised in these team meetings. It would be desirable to tap into explicit consensus tools but current development funding is not sufficient to satisfy this objective.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

There are currently no system functions that allow storage of monitoring data and generation of reports comparing expected values (as generated by models) with actual data that may be collected after project implementation. Data and reports from a project analysis (landscape or project-level) are retained and users can compare these products to data from monitoring, but this comparison is manual at present. However, this issue was discussed during analysis of user requirements, and the system was designed such that these functions could be built in at a later time. The likely scenario would be to establish a database to hold monitoring data, develop data input forms, and develop Oracle routines which generate the needed "expected vs. actual" reports. Design of databases to store corporate resource data is really outside the scope of INFORMS. INFORMS can be used to query and manipulate data in any Oracle database but the existence and management of these databases are not within our control. Monitoring and feedback can be thought of as another tool. INFORMS will support integration of such a tool so that users can execute this tool from within INFORMS.

Feedback from field staff suggests that the real issue with monitoring and feedback should not be these functions but the lack of effort in the USDA-FS to even collect the data needed to support analysis. On most Forests little to no investment is made for long-term explicit monitoring of actions and results after the Forest Plan is complete, thus we have not found any site that has the data, much less a process to automate. Without data, extensive effort in building tools to do monitoring analysis is not cost effective.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

This capacity for the 615 systems to support distributed processing exists but this has not specifically been implemented in INFORMS. It is important that a DSS support concurrent users over a local or

wide-area network. The capacity to do this in INFORMS-DG has been somewhat kludgy and awkward for users.

Feedback from users of INFORMS-DG and requirements analysis have revealed that this is important to development of alternatives and analyses.

## **Spatial Issues**

### **15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

Yes, to the extent that INFORMS is built on top of ArcView and all the functionality of ArcView and ArcInfo is available. Also, these analyses are supportable since INFORMS allows integration of almost any type of analytical tool. Some currently integrated rulebases perform this type of analysis.

### **16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

Yes, alternatives are not only displayed spatially, but the creation of alternatives is primarily a spatially oriented process, wherein the user can assign proposed management activities to spatial features by displaying the appropriate theme and pointing and clicking on the appropriate feature. Alternatives are also temporal: the timing of actions are as important as the location. The INFORMS project database supports both spatial and temporal aspects of alternatives. In addition, some integrated subsystems within INFORMS may perform spatial analysis of alternatives. This analysis is more frequently a function of the tool than of INFORMS.

### **17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

To some extent. Users can analyze large landscapes then select or clip a subset of that area for further more detailed analysis such as at the project level. This capability will be available with the first release of the 615 version of INFORMS. In the long run, the development team has discussed and would like to carry analysis results between these different scales so that users can easily reference previously completed analysis that was done at the larger scale. The current system will track the parent, if any, of each planning project. Parent analyses are composed of spatial and temporal descriptions of future activities as well as the outcomes or analytical predictions. Some tools that users integrate within INFORMS may address this issue as well.

### **18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

Data structures exist to store constraints, issues, and recommendations that are peculiar to a given project. In the long run, these data structures are used to highlight discrepancies between proposed alternatives and the project specific constraints, issues, and recommendations. These data structures can provide useful information to team members in terms of suggested management options and may suggest which models or rulebases to use as tools to sort through various issues. Specific tools integrated within INFORMS are useful for addressing these issues. Current rulebases incorporate policy as in the regional and Forest standards and guidelines, allocative decisions as expressed in Forest Plans, and prescriptive recommendations based on the above information in combination with conditions information. To the extent that it is easy to integrate new tools, users tend to build a "toolkit" of planning tools that they then have available for the appropriate analysis at the appropriate scale.

### **19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

The INFORMS shell handles aggregating and managing the availability of data needed for the planning task based on data requirements of models and tools integrated into the system. Most current tools themselves handle transformation of data as required to drive the model and produce outputs.

## Basic Development/Status

### 20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?

Completely operational on a Sun Workstation and Data General. In transition to the 615 platform.

Two operational and 1 rapid prototype of the ideas representing INFORMS have been built. A DG version was developed and used in the late 1980's and is still being used by a couple of sites in R1. A Sun Workstation version was developed in the early 1990's and is operational on 2 sites in Region 8, the Forest Health field office in Louisiana, and at FHTET in Fort Collins. In addition, the Pine RD in Oregon has tested this prototype extensively. In preparation for transition to the 615 platform, a ArcView-based rapid prototype was built and used to facilitate refinement of user requirements. Staff representing R1, R6, and R8 have reviewed this prototype and helped define the requirements that are driving development of the 615 version of INFORMS.

Transition of INFORMS to the 615 platform is underway. This new release will include functions from previous prototypes plus new enhancements gleaned from user experience with previous prototypes. Three sites in 2 Regions will receive the first cut of INFORMS for 615 by March 1996. By the end of FY96, a more robust and fully functional version will be established at these 3 sites and implementation on other sites will begin.

Beyond the prototypes mentioned, significant products include User Manuals, System Documentation, and a User Requirements document (to guide development of the 615 version). The User and System Manuals will be updated to match the new system during FY96 into early FY97.

In summary, this is NOT a conceptual system or beta version. INFORMS is actively being used on a Sun Workstation on 2 sites and has been for several years. The current track is to reengineer the system to 615 now that we know what that 615 system is.

### 21) Current users: List existing successful applications and users.

Sun Workstation version users: Neches Ranger District, National Forests in Texas, Jessieville Ranger District, Ouachita National Forest, Arkansas

Development, Evaluation, Demonstration, and Test Sites: Pine Ranger District, Wallowa Whitman Nation Forest (Oregon), FHTET (Fort Collins, CO), Pineville Field Office, Forest Health Protection (Pineville, LA), Management Systems, Region 8 Regional Office (Atlanta, GA)

INFORMS-DG on the Data General Users: Deerlodge Nation Forest (Montana), Helena National Forest (Montana), Idaho Panhandle National Forest (Idaho)

### 22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)

We started years ago trying naively to code a truly transportable, fully self contained DSS. The code generation and intensity of maintenance proved impracticable given the USDA-FS budgets and skill bank. Our philosophy is to use the power of commercial systems and let free enterprise pay the salaries to sustain the cadre of highly skilled technical people needed to support hundreds of users across the nation. We try to focus on value added features that are so unique to natural resource management applications that they are not readily available in commercial products off-the-shelf.

The 615 version will work on any 615 system which has ArcInfo, ArcView, and Oracle. With relatively easy recompilation of the minimum amount of C code, the system will work on any unix platform with the above software products. (Note: emphasis was placed on using AML's, Avenue, and Oracle Forms wherever possible to avoid extensive custom C code and thus facilitate ease of long-term maintenance by USDA-FS staff.) User interface is a customized ArcView interface with supplemental windows built using primarily Oracle Forms and to a much lesser extent, a X windows toolkit. The knowledge base component requires the public domain CLIPS product, this is included with the other executables when installed.

### 23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?

Standard 615 equipment is adequate (the Sun workstation version works adequately on an older and slow Sparc2 with 32 MB RAM). The executables and Oracle tables needed to support the system cur-

rently requires less the 20 MB of disk space. Most disk space is used by resource data that is given on any USDA-FS system since they need to keep the data regardless of INFORMS. Disk space required to support project analyses varies. If an existing resource database consumes 100 MB of disk space then a project area which encompasses 20 % of that database will require 20 MB to store the initial project data.

INFORMS copies project area data from the corporate tables/files into project tables/files. Output storage requirements depend on the model used and what output they produce but most sites are using these models anyway (albeit with significant difficulty). The greater the number of alternatives generated and analyses undertaken, the greater the storage needs. The easier the models and tools are to use, the more alternatives the user usually formulates and the more analyses the project team runs.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

INFORMS is specifically designed for the 615 platform (IBM workstations running AIX) but with recompilation of C code can run on any unix platform. INFORMS requires the software that is standard on the 615 platform (ArcView 2.1, ArcInfo 7.xx, and Oracle 7). The knowledge base component is public domain software. USDA-FS sites should incur no additional costs for software in order to run INFORMS. Although Oracle Forms 4.5 is a much better product in terms of ease of use and capabilities, and although the USDA-FS will upgrade to this version before the end of FY96, the developers used Forms 4.0, the current version on 615. This ensures that the application can be used early in 1996 before Oracle 4.5 is available on 615. The INFORMS design is being managed to allow ease of migration to Forms 4.5 when available, and to be able to take advantage of the features inherit in 4.5.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

There are no additional costs other than what USDA-FS sites will already incur in order to maintain the 615 platform.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Funding is already in place to produce an operational 615 version by the end of FY96. This version will include key functions that users have identified. A framework will exist to build in future functions as funds permit. In developing extensive user requirements for the system, users have defined some additional features which were deemed beyond the vision for a first version of the system. These functions include things like a monitoring function as mentioned previously and a robust scoping tool. I would guess that these added functions would require another year or two of development effort at approximately \$75k to \$150k per year to support the staff required.

With our existing cooperator sites and a list of additional sites representing virtually every USDA-FS region who have expressed strong interest in the system (some volunteering to be a pilot site), grass roots efforts will gradually disseminate the system to potential USDA-FS customers. However, an effective technology transfer plan which facilitates getting the system in the hands of as many customers as possible, would require perhaps \$50k to \$75k per year for two years to fund refinements of user manuals, training sessions, and initial support for both implementation, and learning curve assistance. At present Region 8 district and SO staff are planning on forming a user group to facilitate implementation, training, and maintenance. This mechanism will work best in the long run but would benefit from short-term (two-year) funding to ensure success.

In summary, additional resources depend on the demands of users, the vision for the system beyond the initially developed key functions, and the success of the first version. There is tremendous potential for enhancements. The above estimates are perhaps modest to some and extravagant to others.

Project staff currently sketch out development targets for current and two future years. This annual exercise reviews progress, lessons learned, and user priorities. The resulting estimates are refined annually. Below is a summary of these estimates (does not include current federal salaries, facilities, travel, and related overhead):

FY96 (current)

- Data schema implemented which supports all Function Hierarchy functions
- Project Definition functions (includes Team & Role Mgmt functions)

- Project area data management (selection of proj data from corp db)
  - Implementation of Knowledge base component w/ ability to run rulebases
  - Alternative building/mgmt functions
  - Framework for easy integration of tools
    - (at least 2 models integrated to demo utility of function)
  - integrate insect and pathogen successional modeling tools
  - Project tracking functions ("smart menu")
  - On-line help system framework established with most help screens in place
  - User Manual outline with most sections complete
  - Systems documentation draft
  - System operational on three sites with further implementation initiated
  - Draft installation procedures
  - Coordination w/ FVS modeling group and analysis of FVS related issues
- Projected investment to accomplish = \$140,000

#### FY97

- Missing Data functions (routines to assess missing data problems)
  - Scoping functions (utilizes issues, constraints, recommendations data)
  - Integrate data visualization tool
  - complete/refine on-line help system
  - complete/refine system management utilities
  - finalize User, Installation, and Systems manuals
  - further integration of models, particularly insect & pathogen models
  - implement system across multiple regions
  - application certification for agency-wide distribution
  - user support to 2 regional user groups
  - refine project-to-parent planning linkages
- Projected investment to accomplish = \$190,000

#### FY98

- User-driven enhancements
  - concurrent user manipulation of project alternatives including distributed processing functions
  - choice selection support across alternatives
  - integration of high potential tools such as dependency networks, etc
  - monitoring and data transformation requirements analysis
  - final distribution efforts and establishment of user groups
  - revisions to various manuals as needed
- Projected investment to accomplish = \$190,000

#### **27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

The primary target is district staff (resource specialists) with rudimentary computer knowledge. The secondary target is other USDA-FS staff involved with planning tasks such as Supervisor's Office staff and Forest Health Specialists. Once installed, normal day-to-day use will be accomplished by USDA-FS staff without the need for special knowledge in formatting data, GIS, or data management skills. Installation will require involvement by the system manager, but technical skill should be minimized by providing installation scripts and installation documentation (which exists to some extent for current prototypes). USDA-FS staffs taking modest advantage of 615 course offerings should be amply qualified in system installation, management, use, and adaptation.

#### **28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

Although targeted to USDA-FS users, the system has potential use by other entities (our first priority is to sustain compatibility with 615 releases). In fact, at least 2 non-profit groups have contacted the sponsors in regards to their use of the system. Particular interest was expressed in the knowledge base component. Employees of the state of Arkansas helped design some of the rulebases used via INFORMS on the Ouachita NF and are considering adopting this analytical tool for use state-wide.

## Inputs/Outputs

### **29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Input data or resource data is assumed to be stored in Oracle tables. Outputs depend on the tool. Rulebase outputs are stored back into Oracle and thus, easily queried. Formats supported by ArcView are useable since the interface is based on ArcView. ArcView supports transfer of data into documents.

In general, data can be imported into Oracle tables as needed using existing commercial routines. Specific formats required by a model or tool are considered the province of the developers of that tool. INFORMS development has focused on supporting planning functions and the standard USDA-FS corporate platform, and not on developing data reformatting utilities to satisfy countless special circumstances.

### **30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

Yes, it will allow this but this issue is addressed for each model or tool somewhat independently of INFORMS. Tools that require user-specified variables generally include the menus and facilities to collect those parameters. Since INFORMS is designed to allow integration of any model, there is no way to antickpate parameter needs. That is the responsibility of the model, INFORMS does store alternative parameters into Oracle tables as alternatives are built. This standard, documented approach is easily used by modellers to extract what is needed by the model in that regard. In addition, since the knowledge based component was developed in conjunction with INFORMS, the user-specified parameters needed for rulebases are captured by INFORMS through appropriate input windows.

### **31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

INFORMS itself will use whatever data is available as stored in Oracle tables. Specific tools that have been integrated all have different data needs and whether new data is required or not is a function of the tool needs and not INFORMS. The INFORMS data structure will, however, support analysis of data needs for these integrated tools. Long-term plans include development of Oracle routines which can scan existing databases and for each tool, report on the condition of the input data (percent missing, fields missing, age of data, etc.). When tools are integrated within INFORMS, various meta-data tables indicate what spatial and attribute data is required, and the relative value of each particular input item. This data structure now exists, the routines to use this structure to report on data gaps, are scheduled for development in FY97. The necessary requirements documentation to support defining these functions also exists in the INFORMS Requirements Analysis Report.

### **32) Incomplete data: Will the system run with incomplete data?**

As stated above, this question is specific to the analysis tool within INFORMS and not relevant to INFORMS itself. Regarding rulebases, most rulebases use standard resource data, but if data is missing, the rulebase will still run. The user will need to interpret the output carefully given missing data. The display of rulebase output generally indicates missing data problems. There are dozens of models used across the USDA-FS. How the lack of data affects these models is particular to that model. The user requirements and system specifications call for the capability to identify missing data and provide means for simulating data or filling gaps (ref. System Spec 23133 p.IV), but these features do not now exist in INFORMS.

### **33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

INFORMS shines in this regard. INFORMS works directly with existing Oracle databases with no special importation routines required. INFORMS is designed on 615 to be consistent with USDA-FS standards and policies regarding Oracle. The details of the implementation of this function are contained in the Entity Relationship diagram and in other supporting documentation such as the implementation strategy letter that was submitted to IS&T for review and concurrence.



**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Using ArcView as the platform means that all of the mapping and graphing facilities available in ArcView are available with INFORMS. Our unit also sponsors the development of visualization of vegetation data and Forest Vegetation Simulator results over complex terrain. The prototype for this visualization is being re-engineered to be accessed through ArcView also. The principal investigator is coordinating development with other related projects sponsored through PNW & INT. These capabilities, when implemented in 615 based INFORMS, will be more robust than the visualization previously delivered in INFORMS-DG.

**35) Report generation: Describe the types of reports generated.**

No specific reports are produced by INFORMS. As the overall shell providing access to various tools, INFORMS provides user-friendly functions which allow reports and other outputs generated by analysis tools to be transferred into polished reports via use of ArcView's "Layouts". Each site usually determines particular reports they need, and these reports are automated via AML's or Oracle routines, and represented as menu choices through INFORMS. Current users of INFORMS have suggested that standard report templates be established and various analytical outputs be automatically inserted into these reports. The current data structure of INFORMS was designed to support this function, but implementation of the function was considered an outyear enhancement. INFORMS maintains an event log of activities (tools executed, alternatives built, etc.), and this event log would be part of the mechanism used to move key outputs (as configured by the site) into the template.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

INFORMS does not but some of the tools integrated within INFORMS may do this. Our experience has been that most USDA-FS field staff resent black boxes that spit out a decision. These staff want to be able to review the reasons for suggested management actions. In most cases, circumstances affecting management of an area vary so much that a system-generated decision must be further evaluated anyway to account for these circumstances. Assistance in making sound interpretations and understanding implications of "uncertainty" levels of models and data would be useful to any DSS user but are not now included in INFORMS.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

The knowledge base component of INFORMS includes (once defined by the site staff) rulebases which are composed of facts, rules, and coefficients (scores). These rulebases represent expert knowledge from the team involved in designing the rulebase. The approach of the INFORMS design team has been to provide an easy-to-use tool, which allows resource specialists with rudimentary computer skills, to build and maintain these rulebases. Each user site establishes their own security, and maintenance standards for these rulebases, restricting access to editing select rulebases to the appropriate "experts". Existing users have become very comfortable with designing and maintaining their site's rulebases. The Arkansas site currently uses at least 24 different rulebases to perform NFMA and NEPA analysis. Some of these rulebases were validated against actual resource data and found to be quite accurate. The site has full access to update coefficients or redefine expert rules, but again, this access is managed by the site to protect the integrity of the rulebases. Security functions are provided with the toolkit used to build the rulebases.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

No formal training sessions have ever been conducted. With 15 to 30 minutes of verbal instructions and use of the User Manual, users have been able to fully use the system after about 4 hours of practice. The 615 version of INFORMS will assume that users have modest knowledge of ArcView. For comparison,

learning ArcView presents a much greater challenge than learning to use INFORMS and solid ArcView knowledge can be gained by taking a 2 day ESRI class.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

We currently provide full technical support to our user base and are committed to ensuring self-sufficiency of users of FHP-sponsored systems. The system has not been disseminated to the point that technical support has become a significant effort. In the transition from prototypes, to beta versions, to the operational version, sponsors have limited user sites to no more than 3 or 4 sites (this despite many requests from others site to get a copy). Support to these 3 or 4 sites has been provided via phone and site visits by both FHTET and Texas A&M.

Once INFORMS is released to a wider audience beginning late in FY96, plans are to establish regional user groups. In region 8, existing users have already offered to champion this mechanism (it was their idea). On the Ouachita NF, the Forest has restructured their districts partly based on the idea of using INFORMS forest-wide. This Forest is creating 2 centers of excellence which will house GIS and NEPA analysis expertise. The NEPA analysis expertise will be based on using INFORMS to perform planning analysis. The district has already begun to consolidate multiple district databases for use with INFORMS.

The two centers will champion the development and use of rulebases to support analysis as well.

**40) Online support: Is there help available within the system?**

A hypertext-based help system is being implemented within INFORMS. This help system is already partially developed for the Rulebase Toolkit, a separate but related software development effort. The help system in INFORMS will use the same technique as the Rulebase Toolkit. The INFORMS help system should be operational by late FY96 or early FY97.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

Yes, the activity log is represented in the Entity Relationship diagram as the event log. This entity or table will be used by INFORMS for several purposes. One purpose is to help users track what tasks have been completed and what remains to be done. Another purpose will be to track activities of various team members to ensure the project is on schedule. This log can also provide information on where various tool outputs are stored on the system.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

The Rulebase Toolkit used to build rulebases is really a tool that can run independently of INFORMS, but since this software has been an integral part of INFORMS, it warrants comment. When building rulebases the data structures, and actual function exists to store references, and other explanations which document the integrity and basis for the rulebase. When utilizing rulebases within INFORMS, the user has the ability to review this information just as easily as reviewing the actual rulebase output. This robustness is being implemented in the 615 version of INFORMS. A less robust implementation existed on the Sun Workstation version.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

A fairly good set of documentation exists for existing versions of INFORMS. The Sun Workstation version includes an Installation Manual, User Manual, and Systems Documentation Manual. The format of these documents will be retained and the text will be updated for the 615 version of INFORMS. This update of documentation will be done in conjunction with developing the 615 version rather than after the system is built. The Users Manual will be written collaboratively with current end-users. This ensures that the manual is readable and useful by the average field person.

The INFORMS User Requirements Document is a detailed guide to the concepts and functions represented in INFORMS. This document is rare in the Forest Service and represents adherence to CASE methodology principles. Some of the products included in the User Requirements Document include: Entity Relationship Diagram and related products, Function Hierarchy, Function/Entity Matrices, and

detailed prototype evaluations. There are very few software development efforts in the USDA-FS based on this kind of analysis, even though this is the agency-supported methodology.

## Performance

### **44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

In the scope of what INFORMS is designed to support, there is no such thing as a "typical" analysis. There is a great deal of diversity in planning needs across the USDA-FS, and even on a given site, planning needs vary with the planning challenge. Time will vary depending on the number and type of analysis tools used. This application supports the entire IDT process, so a "run" will really include various sub-tasks such as running a particular model. The system is used from project initiation through post project monitoring. Rulebases generally take a few minutes to an hour depending on the rulebase. Model run-times vary in the same way.

### **45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

Once installed, set-up time for each project is fairly minimal, and very easy since INFORMS works directly with corporate resource data stored in Oracle. Users choose the project type (NEPA, NFMA, etc.) which implies a default set of tools will be used in the analysis. Users can add other tools or delete some of these default tools. When defining the project area boundary, the system mandates what spatial layers and attribute tables must be copied to project files based on the selected tools. The system knows which tools need what data. The user has the option to add additional tables or spatial files before executing "clipping" (i.e., the routine that assembles the project data from the corporate database). The time required to copy or "clip" the data from the corporate tables and files into the project tables and files depends on the amount of data. This can take from 10 minutes to a couple hours. However, this is system time and not user time. Once the user selects project type, tools, and data needed via the user-friendly menuing system, the system does the rest.

## Computational Methods

### **46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

All or any of these types of models can be integrated within INFORMS. Current users have used vegetation simulation models, wildlife models, sedimentation models, locally produced complex Oracle queries such as one which classifies stands according to old growth conditions, rulebases driven by stand attributes, rulebases driven by spatial relationships, ArcInfo AMLs. In the near future successional modeling routines will be integrated and thus used within the system.

### **47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

This is an analysis tool issue and not really relevant to INFORMS. The knowledge base component of INFORMS is based on the EMYCIN formula, a method of dealing with uncertainty that was developed by the medical research community. Basically, INFORMS is a data structure in ORACLE with some value added enhancements to support the planning process. The front end is built on ArcView. The data structure is designed to be very generic. The structure will allow attachment of models and keeping track of models which are dependent on the results of previous models. The application can also determine needs to collect more data and/or use data models to generate missing data.

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

- A) Security/Role Management - INFORMS includes team management functions which can be used to restrict team member access to various tools and system functions. Thus only the silviculturist may be granted access to execute certain models. The ability to change critical project data or project parameters can also be similarly restricted. The project leader has the ability to build his/her team by selecting team members from the master list of available resource specialists. This list includes useful information such as the person's phone number, location, and title. Team members can each be assigned one or more roles for the project. These roles determine that person's access to the various system functions and tools.
- B) Missing Data - INFORMS includes the data structure to support identifying data problems and the importance of those problems. The system knows which tools require what data as well as the priority of that data (mandatory, critical, optional, etc.). This structure supports the ability to list those tools which can or cannot legitimately be run due to data condition. In addition, the INFORMS data structure will support integration of software tools that can be used to substitute or simulate the missing data.
- C) Adherence to National Standards and Flexibility - INFORMS was developed specifically to fit within the USDA-FS computing environment with consistency towards IS&T mandated policies and standards. The system will run on any USDA-FS site with the 615 platform with no changes to code required. Custom implementation is accomplished via configuration of INFORMS system tables.
- D) Depth of Analysis - There is unlikely any other similar system in the USDA-FS that is based on such extensive analysis as INFORMS. User feedback was carefully gleaned based on use of existing operational prototypes over many years. As the 615 contract was awarded, user requirements were documented using CASE methodology to create the User Requirements document that is now guiding development of the 615 version of INFORMS. This is a system designed by users for users. Users have always been a part of the development team.

# KLEMS

**1) System/tool Name: Title or acronym of tool.**

KLEMS (Acronym for Klamath Landscape Ecosystem Management System)

**2) Brief description: Short statement of purpose and functions.**

KLEMS is a suite of analysis tools designed and written in close association with land managers at the Forest Service District level to assist in answering fundamental questions in support of management decisions at landscape scales. The tools are designed for use by resource specialists in developing, analyzing, and communicating suggested alternative management actions. The central purpose of the KLEMS development team efforts is to better understand the questions that must be answered and then design tools to help answer them.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

Robert J. Laacke, US Forest Service  
Pacific Southwest Experiment Station  
2400 Washington Ave.  
Redding, California 96001  
(916) 246-5455

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

NEPA issues are not addressed. User defines problems and chooses appropriate analysis tools from those available.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

Analyses are scale independent. Applicable scale for analyses is dependent on scale applicability of data.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

Approaches are not geographically limited. Both data available and the format of those data generally vary with geography as ecosystems and data history vary. Most of the tools are either generic or very simple to customize for local data and individual preference. One tool is specific to a major wildlife habitat data base (California Wildlife Habitat Relationships) and modifications necessary to fit that module to data outside California depend on the type of data used.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

Social and economic elements have not been incorporated to date. Wildlife habitat and stand condition (biophysical analyses) are incorporated.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

The tools provide assessments of current, past, or future conditions depending on the data used. Evaluation of those conditions as desirable or undesirable is left to the resource specialists, ID teams, and line officers.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

KLEMS does not incorporate models or simulators. KLEMS's tools are for analysis and display of conditions predicted by models and other methods appropriate to the location, ecosystem, and question.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Users are required to compare alternatives. The tools are written to provide the analysis assistance.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

Although one of the objectives of KLEMS is to make it possible and easy to prepare and illustrate complex analyses to professionals and general public, there is no explicit provision for public participation or automated analyses for public use. Where public involvement in the development and comparison of alternatives at the analysis level is desired individuals can participate.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

No consensus building capability is included.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

In the sense that monitoring data constitute a description of a land condition they are used in the analysis just as inventory, remote sensing, physical, or other data are.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

The system does not share information because there is no single system to communicate with. Data used are certainly shareable and translatable.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

KLEMS is a suite of tools, some of which evaluate corridors and habitat relationships.

**16) Spatial Alternatives: Does the system display or analyze alternatives spatially?**

KLEMS does not analyze alternatives explicitly as a part of its function. Comparison of alternatives is done by people using KLEMS analysis tools.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

KLEMS does not implement explicit hierarchical functionality on multiscale questions (I think). Interactions across levels are currently identified by users and analyzed with appropriate tools.

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

KLEMS neither recognizes differences, understands consequences, nor offers advice.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

Data are transformed.

## Basic Development/Status

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

KLEMS is in continual development as questions and capabilities change. It is operational in the sense that every tool is used in actual land management activities as soon as it is developed and tested.

**21) Current users: List existing successful applications and users.**

Klamath National Forest: Happy Camp Ranger District, Scott River Ranger District.

Modoc National Forest: Warner Mountain Ranger District, Big Valley Ranger District, Devil's Garden Ranger District.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

Most modules are written for PC for DOS, Windows 3.1x and Windows 95. Several are written for Sun Workstations. Languages include Awk, Basic, Visual Basic, and Delphi (Pascal).

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

KLEMS modules run well on standard PC (8MB ram, 386 with coprocessor okay, 486 or better is nicer). Disk storage depends on data used and data management.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications. (Include price estimates for the tool and other required software.)**

Operating systems include DOS and Sun Unix. Software includes GRASS (public domain GIS — no cost from internet, \$100 commercial supplier), AWK, Windows, IDRISI (GIS from Clarke University — cost ~\$500)

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

There are no annual license fees beyond initial costs for commercial programs that are used. KLEMS itself is no cost.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Development costs are primarily time and travel for members of team. Costs for the next 5 years will average \$200,000 per year for existing salaries and travel in support of development. Efforts contributed by Forests and Districts varies with need and is not formally accounted for.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

The target user of current level of development is the resource specialists and ID teams. Modules for Line officer level analyses are beginning to be developed.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

KLEMS can be used by anybody with data and the interest.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Translation routines for data formats are written when necessary, modules can utilize essentially all PC based data formats from commercial programs (Paradox, FoxPro etc.)

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

KLEMS philosophy is to customize analyses to fit the relevant data. At present, the customization is done on site as part of the joint development. It is possible to automate the process and let the user customize (or will be).

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Data needs are driven by the questions, not by KLEMS.

**32) Incomplete data: Will the system run with incomplete data?**

There are no pre-specified data requirements for KLEMS as KLEMS is not a system per se but a suite of specific tools.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Presently KLEMS imports and exports data, usually without translation.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Visualization depends on ancillary software (e.g. GIS, graphic packages, etc.)

**35) Report generation: Describe the types of reports generated.**

Acreages, patch sizes, and a variety of outputs desired. In most cases the reports are created specifically by the user in response to a need.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

KLEMS does not interpret outputs, make recommendations, or think.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

Functions and knowledge bases are local.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

In the initial development phase on a District, training is scheduled as needed with participants. After initial introduction, self training is usually very productive with assistance as needed.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

To date this has not been a difficulty, and service by PSW has been adequate to resolve questions.

**40) Online support: Is there help available within the system?**

Depending on the module, hypertext help (Windows format) is available.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

The major module (wildlife habitat) does keep a data lineage log.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

Yes.



**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

User manuals and documentation has not been formally evaluated except by users. Most don't need to use documentation.

## **Performance**

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

Analyses take less than 20 minutes on average to run when the land data are available. This does not include the time necessary to conceive the question. Shortest comprehensive analysis took 52 seconds, longest ran 3 hours. Some of this variation was hardware dependent and size of task.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

With clean data the longest time spent was in creating the knowledge base to convert one ecological classification system to another based on local conditions. This took one day to extract rules from a team of local experts, one day to write the conversion program, and 25 seconds to run it. Time to clean a data set is totally dependent on condition of the data. It is quite possible that data sets are judged to be not worth editing and are discarded.

## **Computational Methods**

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

All of the above, except symbolic reasoning, have been used. Application of specific method is dependent on the question being asked.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

KLEMS does not deal with accuracy assessment or error propagation. As we mature!

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

# LANDIS

## 1) System/tool Name: Title or acronym of tool.

LANDIS

## 2) Brief description: Short statement of purpose and functions.

A spatially-explicit model of forest landscape disturbance and succession. This model simulates forest overstory vegetation succession and response to disturbance on landscapes ranging from thousands to tens of thousands of hectares. LANDIS explicitly predicts regeneration, sprouting, and growth of cohorts of trees based on a series of probabilistic equations. Fire and wind disturbance are modeled as probabilistic events. LANDIS is currently calibrated for northern Lake States species. Calibration for Missouri Ozarks in progress. A sub-model to simulate management disturbance is under development.

## 3) Developer/Contact: Name, Organizational unit, address, phone.

David J. Mladenoff  
Department of Forestry, University of Wisconsin  
1630 Linden Drive  
Madison, WI 53706-1598  
(608) 262-1992 (608) 221-6326

For Missouri Ozark Variant contact:

Stephen R. Shifley or Frank R. Thompson III  
North Central Forest Experiment Station  
USDA Forest Service  
1-26 Agriculture Bldg  
University of Missouri  
Columbia, MO 65211-0001  
(573) 875-5341

## Scope and Capabilities

## 4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems?

User must define simulation scenarios with respect to NEPA issues.

## 5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?

Variable scaling. Resolution (i.e. pixel size) can be scaled by the user to match resolution required for specific projects.

## 6) Geographic region applicability: In what areas will it work? Is it limited without major modification?

Currently calibrated for northern Lake States species. Calibration for Missouri Ozarks in progress. Species-specific calibration (based primarily on tree life-history attributes) is necessary for use in other regions. Software has been designed to facilitate re-calibration.

## 7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)

LANDIS deals specifically with bio-physical elements. Predicts landscape-level forest overstory change by ecological land classification units. Models of vegetation change and of wind and fire disturbance do explicitly account for the spatial juxtaposition of ecological units and/or management units on the landscape. Social and economic impacts must be inferred from these spatially explicit estimates of biophysical change.

**8) Analyze current conditions: Does the system produce assessments of "current conditions? What forms of analysis are used?**

Generally, no. Current conditions (real or hypothetical) are used to initialize the model prior to simulation. LANDIS can produce summaries of the initial conditions, but a GIS or statistical package would be more efficient if only initial conditions are of interest.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

Yes. That is its primary function.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Multiple simulations are the means typically used to compare the alternative outcomes. Currently social and economic factors/implications must be derived separately based on spatial and temporal change in bio-physical conditions.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

Maps of alternative outcomes (including change through time) are produced to aid in analysis and discussion of alternatives.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

No.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

No. These capabilities are implicit. Monitoring and feedback activities can be implemented, but familiarity with software and file structure is required.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

Generally, no. However the program code is transportable among PC and UNIX platforms and can accommodate vary large management units.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

Yes. Outcomes through time are saved and can be displayed or analyzed using standard GIS tools.

Yes. By simulating landscape change through time and saving intermediate results, both spatial relationships and their change over time can be analyzed.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

Yes

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

Because the system can be set to operate a relatively small pixel size (e.g. 30m by 30m) most questions of scale can be answered by aggregation (i.e. scaling up). However pixel size is user defined and can be adjusted for match information needs for alternative questions.

- 18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

Only to the extent that the users design these factors into the simulation scenarios considered.

- 19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

Simply aggregated and disaggregated. Transformations are external.

## **Basic Development/Status**

- 20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Operational in the Northern Lake States. Prototype in the Missouri Ozarks

- 21) Current users: List existing successful applications and users.**

David Mladenoff and cooperators have used LANDIS to simulate landscape change in the Northern Lake States.

- 22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

Programmed in C and C++. Works on UNIX and PC platforms

- 23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

Hardware requirements: Variable. Approximate minimum CPU needed, RAM, Disk storage for program and data. Mid-level workstations under Project 615 are adequate. Pentium PC running DOS or Windows also adequate. Data storage requirements depend upon the size of the landscape being analyzed. Virtually any system capable of providing adequate GIS support will be adequate to run LANDIS.

- 24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

Can run under DOS/Windows or UNIX. Requires C++ compiler. GIS (Arc/Info or ERDAS recommended but not required); Use of project 615 software requires addition of a C++ compiler. LANDIS software available with consent of original developers. C++ compiler available in public domain.

- 25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

None. Requires perhaps 3 months of intellectual investment to understand program operation, strengths, and limitations.

- 26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Probably \$400,000 (appropriation level, including salaries and overhead) over next 2 years to complete research and development related to initial implementation of this software in the Missouri Ozarks and analysis of Ozark landscapes. Additional costs of perhaps \$800,000 (appropriation level, including salaries and overhead) to link economic analyses, scenic beauty analyses, forest products analyses, and wildlife analyses to the simulated landscape change.

- 27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Usable by team of experts. Calibration and initial applications have been in a research setting.

- 28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

Yes, it is not specific to any agency

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

GIS files in formats readable and writeable by Arc/Info and ERDAS.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

Generally, no.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Both. Requires maps of vegetation cover and user-define ecological classification units. This information currently exists only for a limited number of locations, but is becoming more widely available.

**32) Incomplete data: Will the system run with incomplete data?**

Yes, it allows those areas on a landscape that have missing data to be excluded from analyses. This may or may not be appropriate, depending on the issues being addressed with the model.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Output can be analyzed by Arc/Info. Input data cannot be read directly from corporate databases other than Arc/Info.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Maps (2-D, in GIS format). Some digital summaries are also possible.

**35) Report generation: Describe the types of reports generated.**

Spatially explicit (GIS) maps of vegetation at user-defined points in time, types and locations of wind disturbance, types and location of fire disturbance. All are in GIS format to facilitate further analysis. Some tabular summaries can also be produced.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

User must interpret outputs.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

As indicated above, coefficients are available for Northern Lake States and under development of Missouri Ozarks.

## User Support

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

This software is not designed for mass consumption. Successful application is probably best accomplished through a team that includes individuals with working knowledge of UNIX systems, C and C++ language, GIS packages, forest vegetation dynamics, associated resource interactions, and forest planning.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

No.

**40) Online support: Is there help available within the system?**

No.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

Very limited

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

No.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

Existent but cryptic. The system is not easily transportable without first meeting with original developers and programmers.

## **Performance**

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

About one day for one simulation of a large landscape.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

A few hours with a clean data set (raster vegetation map with ecological land units identified), assuming excellent knowledge of the program. The difficulty is usually in finding a digital vegetation map with ecological units identified rather than putting that information into the program. Using this program requires a substantial investment in learning the details of the software.

## **Computational Methods**

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

Vegetation dynamics are simulated probabilistically.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

Generally, no. Not explicitly

# LOKI

**1) System/tool Name: Title or acronym of tool.**

Loki (Loki is not an acronym, but an anachronism; the Norse god of cunning, mischief, and fire.)

**2) Brief description: Short statement of purpose and functions.**

Loki is a software architecture for the rapid development of ecosystem simulations. Loki defines a mechanism whereby many individual simulation modules cooperate with one another in a larger, holistic simulation, and provides tools for building the individual modules. Modules built with the Loki application programming interface (API) may be mixed and matched in any manner required by a simulation or DSS application. Building a new system merely requires the selection of appropriate modules from a tool chest of previously-built programs. Loki runs each module as a separate process (executable program). Each module performs a well-defined and limited task such as reading a weather feed, reading or writing a GIS map, updating a fuel moisture map, starting a fire, spreading a fire, digging a containment line, growing a smoke plume, displaying or updating a graph, or displaying and updating a map. A module is never aware of the other modules with which it is running; Loki notifies the module whenever any of its required inputs are changed. The module, in turn, notifies Loki whenever it updates any of its outputs. Because Loki is a software architecture or "middleware", exactly what it does and what its Inputs/Outputs are depend entirely upon the modules developed for it. The benefits of Loki are summarized below under item 48. A preliminary tool kit of Loki modules includes: Weather readers, Dynamic graph displays, Dynamic bar chart displays, Map displays, Image displays, GIS file readers/writers, Fire growth simulators, and Fuel moisture simulators.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

Collin D. Bevins (406) 728-7130

Systems for Environmental Management (406) 549-7478

Intermountain Fires Sciences Lab (406) 329-4874

(Developed under a cooperative agreement with Pat Andrews, Project Leader, Fire Behavior Research)

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

Module dependent.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

Module dependent. Multiple scales may be supported by multiple modules, and aggregation modules may be developed to gather finer resolution data into higher levels.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

Module dependent.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

Module dependent.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

Module dependent.

- 9) **Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

Module dependent.

- 10) **Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Module dependent.

- 11) **Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

Modules may incorporate user/public interaction via keyboard, mouse, or Internet connection.

- 12) **Consensus building capability: Is explicit consensus-building methodology included?**

Module dependent.

- 13) **Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

Module dependent.

- 14) **Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

Loki fully supports and simplifies the distributed processing of its individual modules.

## **Spatial Issues**

- 15) **Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

Module dependent.

- 16) **Spatial alternatives: Does the system display or analyze alternatives spatially?**

Module dependent.

- 17) **Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

Module dependent. Multiple scales may be supported by multiple modules, or aggregation modules may be developed to gather finer resolution data into higher levels.

- 18) **Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

Module dependent:

- 19) **Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

Module dependent. Multiple scales may be supported by multiple modules, or "accumulator" modules may be developed to aggregate finer resolution data into higher levels.

## **Basic Development/Status**

- 20) **Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Prototype.



**21) Current users: List existing successful applications and users.**

CRBSUM

In-house developmental testing.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

Modules use generic ANSI C code for maximum portability. Loki uses the Tcl/Tk tool kit and common network protocols to guarantee portability of scripts and common user interfaces without modification between Unix (X Windows), Intel (Windows 3.1, Windows 95, NT) and Apple (Mac) platforms.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

Minimum 16 Mb memory, 10 Mb disk on Unix, Intel, or Mac.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

Loki requires Tcl 7.5 (or greater) and Tk 4.1 (or greater) on the host machines. Both are available free from Internet. Requires ANSI C (C++) compilers if building the Loki executables and/or individual modules on a local machine. Otherwise, Loki and its modules may be obtained free of charge from developers.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

There are no maintenance or license fees.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Module dependent.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Module developers use the Loki API to build Loki-aware simulation modules. Systems developers use the Loki scripting capability to design simulations and DSS applications containing appropriate modules. End users run the Loki scripts, which may perform any appropriate simulation or DSS task set.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

Loki is agency independent.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Module dependent. Individual modules are developed to perform specific import/export tasks. For example, the tool kit currently contains modules to read/write GIS files in GRASS ASCII and Arc ASCII format, and images may be displayed in bitmap, XPM, PPM, or GIF format.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

Module dependent. Loki uses the Tcl/Tk toolkit for rapid graphical user interface development.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Module dependent.

**32) Incomplete data: Will the system run with incomplete data?**

Module dependent.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Module dependent. Modules may be developed to access/update relational databases, flat files, or live data feeds. Modules may incorporate embedded SQL.

**34) Visuanization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Module dependent. Current tool kit modules support dynamic graphs, bar charts, and strip charts, image display, and 2- and 3-dimensional GIS map display.

**35) Report generation: Describe the types of reports generated.**

Module dependent. Modules may be developed to produce any required reports.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

Module dependent.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

Module dependent.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

Documentation is in progress. No training currently available.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

None yet.

**40) Online support: Is there help available within the system?**

None yet.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

Module dependent.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

Module dependent.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

In progress.

## **Performance**

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

Module dependent.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

Module and application dependent.

## **Computational Methods**

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

Module dependent.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

Module dependent.

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

1. Capable of distributed processing across computer networks.
2. Rapid development of applications from a tool kit of modules.
3. Rapid development of modules using the Loki API.
4. Loki modules may be independently developed by context experts around the world, and the modules will work within a Loki simulation.
5. Separation of processing, display, aggregation, analysis, reporting, and conversion tasks into separate modules.
6. Event-driven processing allows (1) modules to be started/stopped during the simulation as needed, (2) user interaction and needed, and (3) module-specific time scales during the simulation.
7. Loki script files run without modification on Unix, Windows, and Mac platforms.
8. Loki incorporates the highly portable and extendable (public domain) Tcl scripting language and Tk graphics language.

# MAGIS

## 1) System/tool Name: Title or acronym of tool.

MAGIS - Multi-resource Analysis and Geographic Information System

## 2) Brief description: Short statement of purpose and functions.

MAGIS is a modeling system for integrating ecological and social information and scheduling management practices spatially and temporally for a landscape. A wide variety of management practices can be accommodated including alternative silvicultural methods, various logging methods, and practices such as prescribed burning and creating snags for wildlife purposes. In addition, MAGIS contains a transportation component for addressing issues involving roads. Possible network practices include construction or reconstruction, closing, obliteration, and mitigation activities for reducing environmental effects.

## 3) Developer/Contact: Name, Organizational unit, address, phone.

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## Scope and Capabilities

### 4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.

Yes, if the response relationships can be expressed in the form of a look-up table, and if the attributes used in the look-up table are available. We have, for example, calculated such things as water and sediment production by watershed.

### 5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?

The system was designed to conduct analyses of landscapes, up to about 60,000 acres in size. For large areas, stands would have to be aggregated. Data are brought into the system for stand polygons. There is an option for having a separate layer of treatment polygons. This is useful if treatments are applied to pieces of stands or across pieces of stands. Larger areas could be analyzed if stands were aggregated into larger response units.

### 6) Geographic region applicability: In what locales will it work? Is it limited without major modification?

It is not specific to any particular geographic region. Response relationships, costs, etc. are entered by the user.

### 7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)

Some are treated explicitly. Stand structure is projected for each polygon, and acre summaries (and constraints) can be made for them. Other aspects of composition can be addressed as well, for example, acres by density classes, or diameter classes. In addition, users can define outputs that address this as well. For example, the amount of hiding cover and thermal cover provided by polygons can be predicted and summed over appropriate geographic units. Costs and net revenues can also be computed in a number of different ways.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

MAGIS can run a no-action alternative and report conditions at the mid-point of the first time period. At this point it does not report conditions for the beginning of the analysis period.

**9) Predict future conditions: Does the system predict future conditions and evaluate against Desired Future Conditions (DFC's)? What methods are available?**

The model predicts the future conditions for up to five time periods. (This will be expanded to 10 time periods.) User's set the time period length. Constraints can be placed on outputs, costs, acres having specified characteristics, and other quantifiable things that measure DFC's. If a constraint is not met, then the difference is reported. Also, results can be exported into other software for making charts and graphs.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

MAGIS can be used to develop alternatives (choosing activities over time and space) by specifying an objective to max. or min. and by specifying constraints on outputs, costs, acres having specified characteristics, and other quantifiable things that measure DFC's. Results can be exported to other software for making tables, charts, and graphs that compare alternatives.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

Trade-offs can be computed for alternatives using standard mathematical programming techniques. Also, MAGIS has a facility for importing a solution back into the setup phase. There, the analyst can quickly and easily make minor changes in the activities assigned to stand polygons. The effects of those changes are then calculated by making a simulation run. MAGIS output is currently in the form of tables and data files that are exported to GIS software for display. A graphical interface within MAGIS for making some displays will be complete by early summer (1996).

**12) Consensus building capability: Is explicit consensus-building methodology included?**

MAGIS facilitates investigating resource trade-offs.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

None, only in the sense the user can keep the output and evaluate it at future time.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

The system produces DBF files for export to GIS systems. It also produces tabular output that can be stored as ASCII files.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

**Adjacency:** Users can restrict activities on adjacent treatment units over one or more time periods.

**Corridors:** Users can specify a series of corridors options, one of which will be selected. These corridor options (if selected) would be comprised of stands meeting user-specified size classes. Security areas: Users can define candidate wildlife security areas, that if selected, exclude user-specified activities. In the alternative development stage, the user can specify the number of desired wildlife security areas.

Any management relationship built in MAGIS can be developed for any user-defined zone (e.g. watershed, elk winter range). Upper and or lower bounds can be placed on any of these. Management relationships include: output quantities, acres having a specified characteristic (e.g. size class, density class), miles of transportation network with a specified characteristic (e.g. length having watershed restoration, or obliterated), costs, and net revenues.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

The system analyzes alternatives spatially. Map display is currently accomplished through exporting files to GIS software. Map display capabilities within MAGIS will be completed by early summer.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

No

**18) Scale-appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

No

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

No

### **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Partially Operational

**21) Current users: List existing successful applications and users**

Bitterroot Ecosystem Management Research Project (INT Station). Also, the Montana DNRC is developing an application for some of their lands.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

It is currently a PC Windows system. Portability to UNIX Workstation would require lots of work.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

Pentium, 16 MB RAM, 740+ MB of Disk storage

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

FoxPro (\$250) or some other database software capable of producing DBF format files. The following modules of MPSIII/pc are required: MIPIII (a mixed integer programming solver), C-WHIZ (a linear programming optimizer), and a runtime version of DATAFORM system). Advertised price is \$4,000, but the vendor (KETRON) is willing to negotiate on multiple copies.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

MPSIII/pc has an annual maintenance charge of 10% of the purchase price.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Planned efforts currently funded.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Person running system would be GIS or other computer analyst working with District ID teams in the Forest Service. These people could set up data pertaining to the area to be analyzed. Specialists will likely have to be trained to build the output relationships, vegetative response relationships, etc. that pertain to the geographic area where the model is to be applied.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

Yes, this system is being use by Montana DNRC.

## **Inputs/Outputs**

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

The input and output files are database files of DBF format. The tabular output report is an ASCII file.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis.**

Yes, users define the activities to be considered and the costs associated with them. They also define the outputs to be calculated, the variables by which these output vary, and build the resulting look-up tables. Users also enter and define the vegetative size classes.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

New field data

**32) Incomplete data: Will the system run with incomplete data?**

No, there are checks to ensure all necessary data are present. But, the amount of data required depends on the user specifications for the look-up tables for output and cost calculations.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Information can be imported from and exported to Oracle, Arc/Info, and ArcView.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Map display is currently accomplished through exporting files to GIS software. Map display capabilities within MAGIS will be completed by early summer. Current a graphic output module is being completed and such be operational by the summer of 1996.

**35) Report generation: Describe the types of reports generated.**

Tabular reports, and files for export to GIS systems. Also, a database of results is maintained, which can be accessed by other software to produce charts.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

It can calculate a wide variety of outputs, which can pertain to all or specific portions of an area being analyzed.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

The system is designed so that all relationships and data must be entered. We could, however, provide default data sets.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

No training session has been conducted to this point. I would expect that future sessions that cover all aspects would last about three days. Applying the model once data relationships have been entered is somewhat intuitive, so self-training for this portion may be feasible.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

No, we are working on some arrangement.

**40) Online support: Is there help available within the system?**

Yes, on-line help is available.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

Yes, activity logs from several MAGIS process are written to ASCII files. Also, separate error logs are written and can be viewed or printed from the menu system.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

No.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

Online is help about 75% done. The user manual being written now, with a complete draft by April 1996.

## Performance

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

The time it takes to generate the pre-matrix table and process the pre-matrix tables to create the matrix could take up to 3 days depending the number treatment units, management options and time period per treatment unit, and the number of outputs.

Solving the Matrix once created: Solving an alternative in simulation mode (all decision variable set by user or the user imported a previous solved model and modified the previous selected decision variables) takes a couple of minutes. Solving an alternative using the LP solver is 10 minutes or less. Solving an alternative using the MIP solver based on finding first feasible solution takes 15 minute to an one hour, but can vary greatly by problem. Often the first feasible solution is within 10 percent of optimality. The amount of time required to make a significant improvement from the first feasible solution could take an additional hour or more.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

Assuming clean data, and that the basic relationships have been developed previously, 4 - 8 days.

## Computational Methods

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

optimization

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

No.

**48) Identify particular system strengths that are not included in the above list of attributes.**



# NED (Northeast Decision Model)

## 1) System/tool Name: Title or acronym of tool.

NED

## 2) Brief description: Short statement of purpose and functions.

NED uses a prescription design system to incorporate management goals for multiple objectives, analyze current forest conditions, produce recommendations for management alternatives, and predict future conditions under different alternatives. NED assists in evaluating silvicultural decisions at a project level using landscape-scale factors.

## 3) Developer/Contact: Name, Organizational unit, address, phone.

Mark J. Twery, USDA Forest Service  
PO Box 968, 705 Spear Street  
Burlington, VT 05402  
802-951-6774

System is in development, with intermediate products in use by various publics. Comprehensive analysis package is due before the end of 1996.

## Scope and Capabilities

## 4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.

Analyses and scope are user-defined.

## 5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?

The system is designed to be used to develop multiple stand prescriptions using landscape scale information, goals, and analyses. Finer scaling is easily feasible, but it is not designed to handle regional-scale questions.

## 6) Geographic region applicability: In what areas will it work? Is it limited without major modification?

NED is designed for forests of the eastern US. Some features will work anywhere, but much of the analysis is specific to the forest types.

## 7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)

The system is designed to include a specified, limited set of goals to be selected by the user. Beyond these, social elements are treated only implicitly — the system assumes that goals have been pre-selected using some process outside the system.

## 8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?

Yes. NED's focus is on integrated assessments of current conditions, using a mixture of rule-based or knowledge-based methods, simulations, simple summary computations, and other analyses.

## 9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?

Yes. Future conditions are generated by a combination of simulations and rule bases and compared against DFC's using additional rule bases.

- 10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

The system is designed to be flexible, including both structured and unstructured analyses and comparisons of alternatives.

- 11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

Yes.

- 12) Consensus building capability: Is explicit consensus-building methodology included?**

No, but its ease of use, openness, and low cost platform make it easy to adopt in consensus-building situations.

- 13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

No, not explicitly, but it is feasible with some effort.

- 14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

There is no explicit facility for distributed processing.

## **Spatial Issues**

- 15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

Such capabilities are being investigated but are not yet designed. Some minimal adjacency analysis is being designed into the knowledge bases.

- 16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

Some spatial display and analysis is planned but not yet implemented.

- 17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

Interactions among visual, wildlife, and timber resources, for example, are treated at appropriate levels for the different benefits, according to knowledge bases developed by regional experts. Scales addressed range from stand to landscape.

- 18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

NED addresses local prescriptions primarily, with some allocative decision support, but does not deal with higher (regional, policy) scales.

- 19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

The treatment varies with the type of data. Volume summaries, for example, are aggregated, while wildlife habitat is transformed based on knowledge bases.

## **Basic Development/Status**

- 20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

NED is partially operational, partially prototype, and partially conceptual.

**21) Current users: List existing successful applications and users.**

Operational pieces of the NED project include NED/SIPS and the Forest Stewardship Planning Guide. NED/SIPS is in use by the Massachusetts Department of Environmental Management for inventorying of their State Forests, plus many consulting foresters (contact Neil Lamson, USDA FS, S&PF, Durham, NH). The FSPG is also in use by consulting foresters and educators around the Northeast. The Green Mountain National Forest and Monongahela National Forest are experimenting with using both programs and in helping design the full system.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

NED is being developed currently in Windows on a PC platform using C++ and an application framework called "C++-Views", plus some of the rule base programming is in Prolog. These choices were made to facilitate easy portability to an X-Windows platform such as the new Project 615 configurations.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

Minimum hardware requirements for the Forest Stewardship Planning Guide is any computer that runs Windows 3.1. NED/SIPS requires a 286 or better with 500+ free memory in DOS. The full NED system will require at least a 486 running Windows. Minimum storage for program and data is expected to be about 5 Mb.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

NED is public domain and is available on request. No additional software is required beyond the operating system for the platform (Windows or X-Windows).

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

Maintenance costs and license fees are Zero.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Planned development and enhancement efforts extend for approximately 4 years at approximately \$400K per year.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Target users are field resource managers including consulting foresters, district biologists, industrial land managers, and others. Data should be collected and entered by appropriate field crews.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

Yes. The National Forests are an important user group but are by no means exclusive.

## **Inputs/Outputs**

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Data are used in ASCII format. The system will import and export data in .dbf and Oracle formats.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

Yes, to a limited extent or greater capability with minimal programming by the user.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Both traditional and new data types and variables are used.

**32) Incomplete data: Will the system run with incomplete data?**

Yes. Users will be notified that data are incomplete and assumptions and defaults will be identified.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Import and export functions are in development.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Graphs and charts are included as are tabulated outputs. Visualizations including simulated views and representative photographs are planned.

**35) Report generation: Describe the types of reports generated.**

Reports in narrative, tabular, and graphical form describe current conditions, dfc's and the differences among them for different alternatives. Measures reported on include various summaries of timber, water, wildlife, and visual resources.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

Some interpretations of output are planned, limited generally to descriptions of how well conditions under a certain alternative match dfc's as specified by user-identified goals.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

Both methods are or will be available and will be user-chosen or identified.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

Training sessions are planned and range from half-day to 4-day sessions, depending on the depth of the specific session and the target audiences. For many applications self-training is very feasible. For the Planning Guide no training is necessary for a user familiar with Windows.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

Yes, the developers are available to answer telephone questions. If demand becomes too great, we will try something else.

**40) Online support: Is there help available within the system?**

Yes. Built-in help systems are available in all NED products.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

Yes. NED/SIPS and NED have or will have activity logs and data lineage facilities.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

Yes, the full NED system is planned to provide extensive explanations and references.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

NED/SIPS and the Forest Stewardship Planning Guide both have manuals that are adequate for getting started and following cookbook steps within the program. They lack completeness in references for where some steps derive from, depending on the online help system to provide some of that facility.

## **Performance**

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

Runs are complete in a few seconds to several minutes depending on the complexity and extent of the run.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

Generally several runs can be set up and run on a scale of hours or less for most applications of NED. Some may take longer if extensive data importation is required or if the area of consideration is large.

## **Computational Methods**

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

All of the above techniques are used at various points in the NED process.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

Sensitivity analysis can be done explicitly with several financial functions within NED or implicitly by the user's manipulation of input variables. Accuracy and uncertainty are recognized as potential variables of interest but have not yet been addressed.

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

# RELMdss

**1) System/tool Name: Title or acronym of tool.**

REGIONAL ECOSYSTEM AND LAND MANAGEMENT DECISION SUPPORT SYSTEM: "RELMdss"

**2) Brief description: Short statement of purpose and functions.**

RELMdss is designed to be an integration, analysis, and display tool for the generation and implementation of forest and land use plans. RELMdss currently operates in the Windows environment on a personal computer. One of the key features of RELMdss is that potential plans are depicted through the use of map-based displays to facilitate rapid comprehension of results. The effects of various existing or proposed allocations, standards and guides, and treatment schedules can be evaluated related to meeting multiple objectives or desired future conditions across several time periods and scales.

RELMdss provides not only optimization models which allow the user to interactively adjust activity or constraint levels, but also includes management and display of Hierarchical planning linkages. RELMdss provides the necessary tools for managing different levels of data and displaying the data in one system simultaneously.

An additional feature of RELMdss is the capability to display and interpret planning information externally generated by other systems along with map-based overlay features such as roads and streams and images or pictures of actual landscapes.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

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Department of Geography  
University of California, Santa Barbara, CA 93106  
church@geog.ucsb.edu (805) 893-4217

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

User needs to define the problems. One must describe the problem in terms of Targets, Objectives, Thresholds (constraints), State Variables, and Desired Future Conditions at the various scales of hierarchy that one wishes to analyze.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

This is an hierarchical model that can function at multiple scale/levels simultaneously.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

Independent of region/locale

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

User must translate these variable into RELMdss input.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

The SCENARIO analysis within RELMdss measures the current condition existing under the present plan. This allows a basis of comparison when new model/plans are analyzed through the system.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

A modeling and display feature of RELMdss is the analysis of DESIRED FUTURE CONDITIONS (DFC'S). The idea of a DFC is that management of land is driven in part by the need to move such lands into ideal states or conditions in later time periods. RELMdss can display whether such conditions have been met as well as provide optimization solutions for transitioning lands into such states. The sequence of activities to meet this objective is also defined.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Alternatives are displayed in the form of thematic map displays and tables for each time period in the problem. Targets, objectives, thresholds, and desired future conditions are explicitly displayed over time along with any additional attributes of interest.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

One of key feature of RELMdss is that alternatives are developed in "real time." It typically takes less than 1-minute to re-optimized a new alternative which facilitates public participation.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

The system can provide information for consensus building, but it is not a consensus building model.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

RELMdss has explicit features that allow cumulative effects and connected actions to be evaluated between units over time at multiple scale/levels.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

Presently, the model has capability to generated outputs that are in a format useable by all major spreadsheets and relational databases (RDB) as well ARC-VIEW. Currently there are no direct data links with other units built within the system.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

RELMdss can detect and display adjacencies, but cannot optimize on the basis of juxtaposition.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

RELMdss displays and shows the effects of alternatives spatially but cannot optimize on polygon-to-polygon juxtaposition variables.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

RELMdss has a built in hierarchical manager for moving information between levels/scale and re-optimizing based on this data. Any number of levels can be specified. Therefore the "ripple" effects of a change in schedule on one unit at a given level can redistributed to remaining units at other levels/scales subject to meeting a given set of management objectives.

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

User must define within context of the input.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

Data is both aggregated or transformed as it moves to different levels. Data movement can be either upward or downward.

## **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Fully operational

**21) Current users: List existing successful applications and users.**

Forest Service Regions 5 & 6, Sierra Nevada Ecosystem Project, Caribou NF R4, State of Oregon BLM.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

RELMdss is developed in C+. It runs under Windows 3.1 or newer.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

System Requirements include a 486dx with at least 8-mb of memory, and a monitor with screen resolution of 800x600 or better.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

System requires C-WHIZ Linear Programming software version 1.4 or newer. Cost of C-WHIZ is approximately \$800 per package.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

N/A

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Continued Program Development costs are approximately \$60,000 per year.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Decision-makers and planners at all levels. Analysts with support from resource specialist will develop input, planner or decision-maker will run.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

System is being used outside the Forest Service.

## **Inputs/Outputs**

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Comma delimited data flat file for both input and output. Presently pre-processors exist for taking data from ARC-INFO and SPECTRUM to build input data sets.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

No.



**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Both new and existing data can be utilized.

**32) Incomplete data: Will the system run with incomplete data?**

System requires data for all units; however, data maybe at different resolutions.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

System imports data from corporate data structures. Transformation of data is required.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Thematic maps, charts, tables, overlays, and pictures.

**35) Report generation: Describe the types of reports generated.**

Screen Capture and comma delimited flat files that can go directly to spreadsheets or relational data-bases.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

N/A

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

Default data comes from the existing forest plan or program.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

2-day training session is available and given at least once a year.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

Hot-line is available.

**40) Online support: Is there help available within the system?**

**41) Self-documentation: Does the system keep an activity log and data lineage?**

Activity log but no data lineage

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

Window Help function only

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

User's Guide (Print and under Help Function)

## **Performance**

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

Approaches "real time," usually less than 1-minute; typically 20-seconds

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

2 to 4 hours.

## **Computational Methods**

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning**

Optimization (linear programming)

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

n/a

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

1. Near real-time performance
2. Multiple scale/level and time periods
3. All contained on a PC-laptop
4. Conversion programs to link Arc-Info and Spectrum to RELMdss exist.

# SARA

## 1) System/tool Name: Title or acronym of tool.

SARA (Spreadsheet Assisted Resource Analysis)

## 2) Brief description: Short statement of purpose and functions.

SARA is a set of programs and templates for free-form procedure for matrix generation and report writing to build and evaluate solutions of linear programming models of forest ecosystem planning models. The programs work with any commercial spreadsheet and linear programming solver. The most common programs used are QuattroPro and EXCEL for spreadsheets and CWHIZ and LINDO for linear programming solvers. SARA programs can directly construct a bottom-up hierarchical planning model by pulling alternative solutions for sub-units as the integer decision variables into an aggregate model for the larger planning unit.

Because the essential data and model building is done within a commercial spreadsheet, it is easy and inexpensive to share an understandable analysis process with all interested constituencies and greatly enhance model credibility and consensus building. SARA is easily connected to GIS and related data bases on the input and output side of the linear program. SARA has been extensively tested in teaching, large scale research models to determine economic-ecological tradeoffs, and in landowner strategic planning applications over the past 5 years.

## 3) Developer/Contact: Name, Organizational unit, address, phone.

Dr. Greg Biging, DIRECTOR or Dr. Larry Davis  
CAMFER, 145 Mulford Hall  
University of California  
Berkeley CA 94702  
Telephone: 510/643-2028  
FAX: 510/643-5438

## Scope and Capabilities

### 4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.

SARA does not automatically handle NEPA questions or issues. The user would have to specify the output or other information needed to answer these issues and then design the SARA model to provide them.

### 5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?

Any spatial scale can be incorporated into SARA models or an aggregated set of models. We have built very high resolution models for areas as small as 3000 acres and moderate resolution multi-ownership, multi-watershed models for areas as large as 200,000 acres. Conceptually there is no reason the analysis cannot be extended to National Forest or Region scales of work.

### 6) Geographic region applicability: In what areas will it work? Is it limited without major modification?

The model works in any area or region. SARA itself contains no data or coefficients and has been applied to problems ranging from agroforestry problems in India, Pakistan, and Sri Lanka to The Flathead Indian ponderosa pine forest and both redwood-Douglas fir and mixed conifer forests.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

SARA can explicitly treat social, economic and ecological attributes and projected outputs from alternative policies for management of a subject forest ecosystem. The necessary model structure and data would have to be designed/developed on the input side to provide the desired information. Available demographic data bases, forest inventory, and mapped resource attributes can be processed using GIS and associated simulation systems.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

SARA can analyze the current condition in two ways. First, the linear programming model is constructed, the current status of all tracked forest input and output values can be calculated for the initial state (Time=0) and reported.

Second, most of our analysis applications thus far also involve assignment of the linear programming solutions to map polygons and spatially projecting future vegetation and structure in a GIS environment. The current and projected vegetation structure is evaluated for diversity, connectivity and species-by-species habitat suitability. The current vegetation map can be evaluated by a variety of current spatial evaluation programs. In a similar manner the soils, topography, etc., can be processed through erosion, landslide and other spatially defined physical and biological models for assessment of current condition.

**9) Predict future conditions: Does the system predict future conditions and evaluate against Desired Future Conditions (DFC's)? What methods are available?**

To continue question 8, the spreadsheet templates developed in SARA applications have worked out in detail the formulas and procedures for tracking future areas in different size, species and density attributes by watershed subunits and for the planning unit as a whole. These are carried in the linear program as a set of forest output variables for each planning period. The variables are used for reporting of the future forest structure on a period by period basis.

The variables are also used to develop ecological policy for minimum or maximum amounts of structural types by period or for establishing in a goal program the objective of minimizing the deviations from a temporally staged desired future condition. Ecological variable and some form of ecological policy has been used in virtually every SARA forest ecosystem application.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

SARA has a specific program called MATRIX that is used to facilitate spreadsheet-based comparisons of a linear programming solutions that portray or represent different policy options. Each solution is stripped down to the columns/value section of the commercial LP report and imported into the spreadsheet for evaluation. Each solutions or alternative is a columns of values in the same variable order and extremely easy to construct line, area or bar graph comparative graphics.

The graph formats developed can become automatic templates simply by importing the data for a second set of alternatives in the same column order and pasting over the initial set. All that needs changing is the graph titles and legends. This has to be extended in one application to writing a spreadsheet macro to do this. A batch file pulls in the new solutions and the next thing that happens is the graphs start coming out of the printer. Anyone who can work with spreadsheet formulas and macros can customize this type of work.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

SARA was built with public participation in mind. The lack of rules and formats and the use of commercial spreadsheets provides a medium for model building and analysis with which a great many people are familiar. Because the entire model and the input data can be directly examined in a spreadsheet, the question and issue of data quality and the response of land types to the implementation of a proposed prescription (a column) can be evaluated by anyone.

Once it is agreed that the biophysical treatment response model — we call it the Resource Capability Model — is a reasonable or acceptable portrayal of the subject forest ecosystem given the state of current knowledge and data, then attention can be shifted to the policy model(s) and how the forest ecosystem responds to them.

We have used this system in an extended series of public sessions to facilitate the development of forest practice rules for private lands. The participants had radically divergent values. After a series of tutorials, discussion sessions and model evolution, the debate shifted from criticism of the data and “the model” to the normative issues of policy such as the appropriate desired future condition and the appropriate rate of buildup of forest inventory.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

For the reasons discussed in 10 and 11 above, SARA helps constituencies to approach a consensus. Of course not everyone wants to know or quantify the projected implications of policies and prefer to use legal and political strategies to achieve their desired outcomes. However experience shows that the SARA formats of information, analysis, and presentation have helped push the process in the direction of negotiated consensus. If nothing else it has removed or greatly undercut the “black box” arguments that are frequently used to discredit analysis.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

SARA itself does not address monitoring and feedback. If it is being used in connection with a monitoring, data base, GIS information base, that continuously update the inventory plots, maps and area by land then SARA could be useful to update implementation and forest outputs projections and compare the updated or “new” current and future projections with previous projections.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

A variety of distributed processing configurations would be possible with SARA. All the inventory, GIS and data base could be done remotely from the model building and policy analysis and public participation work. The construction of commodity, social, economic and ecological yields from growth and yield analysis of inventory plots under candidate prescriptions could be done separate from the linear program work but it is not desirable.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

SARA models deal with spatial analysis to the extent that stands, watersheds, political or administrative units are explicitly recognized in the decision variables of the linear programming model. Most of our applications have recognized at least one level of geographic sub-units, usually watersheds. Stand- or polygon-level spatial analysis is/has been done in a GIS environment.

A set of assignment algorithms have been used to assign a prescription to each polygon or raster cell that is consistent with a given linear program solution and some spatial configuration policies. Working back and forth between the linear program and GIS is an important aspect of SARA analyses.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

Spatial alternatives for a given linear programming policy solution are generated by repeatedly running the stochastic spatial assignment algorithms and then evaluating them for different spatially dependent forest outputs such as wildlife habitat suitability. Some emerging programs are in a test stage for introducing stochastic natural disturbances such as fires, insects, climate or demographic change which override any deterministic mapped plan and generate a variance and as well as mean value of expected spatial and statistical outcomes of a given policy alternative.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

Hierarchical planning is explicitly done using the MATRIX program of SARA. The same set of alternatives imported for reporting purposes (as discussed in question 10) also can be run through the matrix generation program EQUATION to generate an integer (0,1) model that considers the alternative for each sub-units as decision variables in a higher, multi-planning unit hierarchical level.

Aggregating several watersheds to a National Forest or several Forests to a regional models would be example applications of this. The aggregated integer model itself is small and easy to understand, a good vehicle for public involvement and consensus building. We have used these integer models in several applications to combine the outputs of multiple landowners within a given geographic landscape.

**18) Scale-appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

The user can design a hierarchy of models, prescriptions, and policies appropriate to the different political and geographic scales in question.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

Other than user decided aggregation, data are not normally transformed at different scales. It would be possible to design a system to do this however.

## **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

The current status of SARA is operational. It has been used for over 6 years in classes, research and applications. A few modest changes in the four basic programs have been made over time and several utility programs have been developed to help process input data, work with large scale problems, and to link the linear programming solutions to polygons or raster cells of a GIS data base for spatial projections and evaluations.

**21) Current users: List existing successful applications and users**

California Department of Forestry (sustained yield plan), Blodgett Forest Research Station (sustained yield plan), Hoopa Indiana Reservation (strategic forest plan), and the Flathead Agency (strategic forest plan). Policy analysis to develop multi-owner strategies to improve the wood supply for the province of New Brunswick, Policy analysis for the proposed Sinkyone intertribal Indian forest, Policy analysis for Mendocino County Forest Practice Rules, Policy analysis for California Ballot Initiatives, and Policy analysis for goshawk habitat, R3 USFS. Over 15 corporations and consultants plus over 20 universities are using this software. I do not know the kind or extent of the applications for many of them. In our research models we have developed detached matrix coefficients for problems with over 30,000 columns and 3,000 rows.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

SARA programs and ancillary growth and yield, ecological classification and assignment algorithm utilities are written in Turbo PASCAL and have been used extensively on 386 and 486 PC computers; the more memory and speed the better. The new stochastic disturbance programs are written in C++ and run in UNIX. We have only used DOS-based versions of spreadsheets, CWHIZ and LINDO. If these are available for workstations the programs could probably be rewritten for this platform.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

We find that SARA is amazingly fast and adequate to the task on the current 100+ Mhz. Pentium machines with 16 MB of RAM and .5+ Gigabytes of hard disk. For very large problems 32 MB of RAM and 1 or more GB of disk are helpful. A running GIS system is a necessity for site specific analysis. A workstation with capacity for a program like ARC/INFO would be necessary to do this effectively.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

The SARA software consists of four main programs (EQUATION, MATRIX, REPORT and TABLE executables), the utility program for ecological classification (both source and executable programs), and a dozen or so example worksheets for application programs which can be used for templates and teaching. The cost of this is \$250 for a site license. The user also needs to purchase a copy of CWHIZ or LINDO and a commercial spreadsheet that can save worksheets in \*.WK1 format.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

None. UC does a little technical support and can arrange contracts or consultants if needed. Only a few times has this proved necessary. The programs seem to be free of "bugs" and most of the real problems encountered have to do with not knowing how to build forest planning models rather than the software. Occasionally UC will release a new release for a modest cost.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

There are no plans for additional software development. The current programs and the spreadsheet vehicle are so generic we foresee little need for development. Most of the application work and custom programming involves making use of the formulas and macro language of the spreadsheet being used.

Multiple and linked spreadsheets and macros that build spreadsheets are commonly used on large scale application problems. UC can supply templates and examples but most applications wind up writing custom formula and macros for their own purpose. There is considerable documentation and commercial support for spreadsheet application techniques.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

The primary users are the management/landowners and the analytical staff of a forest land ownership. Often consulting companies served the role of staff. At least one analyst with knowledge of linear programming and the construction of LP models is essential. Additionally the analyst should have skill with spreadsheets and basic DOS/PC operations. Supporting staff and silvicultural/biometrics skills are needed to generate the needed yield tables. SARA puts a great deal of stress on knowing the accuracy and quality of the yield tables used.

Management can quickly understand the nature of the models and where they fit into the model design and applications. In our applications corporate executives, legislators, and high level agency executives could easily follow the basics of the analysis and the tradeoffs between goals and values.

The participating public is the second major target audience. The choice of spreadsheets and style of model building has been shown to greatly increase the understanding and model credibility of these participants. It's extremely easy to develop citizen policy or citizen alternatives for consideration and collective learning.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

The model is completely agency independent.

## Inputs/Outputs

### **29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Data can be in nearly any form and imported into a spreadsheet. Generally tabular formats are best. What is necessary is to agree on the names and codes of land types, prescriptions, and forest input and outputs to be tracked and to be sure that all yield, ecological, economic and other data is keyed to these names and codes. This is much the same as setting up all the identifiers, activity and output codes in SPECTRUM (FORPLAN) and then being careful to key all data to them.

### **30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis.**

The spreadsheet approach allows almost any user-specified set of names, codes and data formats desired. The only real rules are to maintain row order in multiple spreadsheets and to stay with eight character row and column names with no embedded blanks.

### **31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Both. But then I don't know what traditional data is. Models could be built with the kinds of data that has been used in FORPLAN. However the FORPLAN yield files I know do not adequately treat ecological structure. What is required is to re-run the growth and yield analysis to generate all the needed ecological variables.

### **32) Incomplete data: Will the system run with incomplete data?**

SARA Programs do not address incomplete data. The CACTOS and CRYPTOS and I believe FVS have utility programs that will fill in missing data such as tree crown length. An accurate individual tree inventory that measures the species, diameter, height, and height to the base of live crown for every tree on a sample plot as well as snag, dead-and-down, shrubs and forbes, is standard for data to support credible ecosystem management analysis.

### **33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Reports are produced in the spreadsheet to any format and style the user desires. Spatial reports are possible when the solution is linked to GIS and ArcView through a spatial assignment algorithm.

### **34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

SARA primarily uses the spreadsheets to build attractive colored graphs and charts from which hard-copy, slides, and data-show demonstrations are made. In the last two years the assignment algorithms working with ARC/INFO GIS data bases created current and future vegetation maps. These were evaluated for diversity and wildlife habitat. These results can now be digitally "grabbed" and shown in the new ArcView software for the PC. All manner of creative visualization and graphics are now possible.

### **35) Report generation: Describe the types of reports generated.**

No written reports are generated. Only the basic data, results, charts, graphs and maps as described above. With \*.BAT programs and macros, much of this can be automated.

### **36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

The system does not automatically "interpret" outputs, it just presents the quantitative map, graph and tabular results of the primary solution. Perhaps I'm not sure what this means — we do color and aggregate to simplify and make the results more easy to comprehend. Anything done is under the control of the user.



**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

There are no default coefficients or data of any kind in the SARA programs.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

Training is available through the CAMFER center. Over a dozen experienced users are available to serve as instructors and consultants. A one-week course gives beginning forest planning modelers a good start while experienced people that know spreadsheets, linear programming, growth and yield models, and have experience with forest modeling can pick up SARA in two days. Training courses (approximately six weeks long) have been offered for SARA with approximately 12 persons attending each session. Each of these courses involved over a day on the basics of forest modeling, perhaps a day on using the SARA programs, a third day for an orientation to using growth and yield models to build ecological "yield" tables and use of spreadsheets to build a simple model. The last two days are spent in running the student model and some larger models to do policy analysis of joint economic ecological goals and for special topics such as use of multi-spreadsheets for large scale production problems and a survey of current and planned applications.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

A low level of user support is available through CAMFER. In our experience very little support is needed. The programs have no known bugs and the commercial programs are well supported. Most questions relate to "how to model a specific output or issue?"

**40) Online support: Is there help available within the system?**

No on-line support is provided.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

There is no activity and data log for the primary SARA programs. CWHIZ provides a log.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

There is none.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

There is a users manual keyed to a test data set. The manual uses the test data in a tutorial style to explain how the primary programs of SARA work and some of the many possible variations in problem formulation. This users manual has been tested through all the short courses and through at least 6 years of college classes in forest management. It seems to be satisfactory as few complaints have been offered in course evaluations. The manual is simple because there are almost no rules to restrict model formulation.

Several sample worksheets of real applications are provided and are documented within the worksheet itself. A related work book is available called Analysis of Agroforestry Systems that uses the SARA system and provides many additional example application problems and test data sets. The commercial spreadsheet and linear programming software all have well developed documentation and user guides.

## Performance

### **44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

Assuming the spreadsheet RCM exists and one or more Policy models have been written in a text editor, the SARA programs take very little time to run, on the order of 10 to 20 minutes for large problems. Running an 8 MB LINDO format file (for a 20,000 column by 2500 row problem) into CWHIZ and solving the linear programming takes about 20-40 minutes depending on constraint complexity.

### **45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

All the serious time is spent developing the set of spreadsheets and the yield tables. The first model takes the longest, after that the original model typically serves as the template for new models. For any new model with new (but complete and accurate) inventory, prescriptions and yield simulators, it's easy to spend a few months generating yields in an interactive process with ecologists, silviculturists, various critical publics before a final and commonly acceptable table is developed. Fortunately this only has to be done once.

## Computational Methods

### **46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

In SARA proper we are dealing with deterministic optimization with linear programming. Goal programming, chance constraints, and various sensitivity interactive and sequential techniques can provide for inductive reasoning and learning, fuzzy logic and various ways to deal with risk and uncertainty about data or values. To build SARA models we use growth and yield simulators, erosion, wildlife, economic and other simulators.

### **47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

Know accuracy of the inventory and spatial data is the primary source of accuracy assessment. Sensitivity analysis in the linear program is the primary route to risk assessment. When the model is linked spatially to a GIS then stochastic spatial disturbances can be simulated.

### **48) Identify particular system strengths that are not included in the above list of attributes.**

Anyone can quickly learn how models are put together, what data they contain and how policy or rules for forest ecosystem use and development direct and control the choices about which prescriptions are chosen for which land type. SARA facilitates a clean separation of questions of fact and questions of value. The questions of treatment-response data quality and accuracy can be cleanly separated from the more difficult issue of conflicts between goals and between the values of different constituencies. All this helps building consensus in a politicized decision making.

# SIMPPLLE

## 1) System/Tool Name: Title or acronym of tool

SIMPPLLE (SIMmulation of Patterns and Processes at Landscape scaLEs)

## 2) Brief description: Short statement of purpose and functions

SIMPPLLE consists of an object-oriented design that allows for flexibility in the level of detail used to characterize existing vegetation and the processes that drive change. Using processes (insects, diseases, wildfire) and management treatments, the system provides simulated change in vegetative states. The system includes interaction between processes and vegetative patterns. Numerous stochastic simulations provide the means to understand and quantify the variability in landscapes to help determine realistic desired future conditions. Stochastic simulations provide the basis for evaluating alternatives within the context of a dynamic landscape.

## 3) Developer/Contact: Name, Organizational unit, address, phone.

Jim Chew, RWU 4151, Intermountain Research Station, 800 Block East Beckwith, P.O. Box 8089, Missoula, MT 59807, 406-542-4171

## Scope and Capabilities

### 4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.

User must define. The analyses to be addressed helps to identify the level of description used for existing vegetation and what processes are to be included as agents of change.

### 5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?

What should determine the scale at which SIMPPLLE is used is the analysis being performed. At what scale do the processes of interest function, and at what scale is it necessary to evaluate the potential of a landscape to provide certain functions? Individual plant communities are the basic units in SIMPPLLE, but the object-oriented design allows for flexibility to represent them as polygons or pixels of any size and any total number.

### 6) Geographic region applicability: In what locales will it work? Is it limited without major modification?

The underlying object-oriented design that provides the basis for characterizing existing vegetation; capturing knowledge of change in parallel potential vegetative states; providing for the behavior of insect, disease, fire and weather related processes of change; and provides for the interaction of processes and patterns, should be independent of geographic regions. Within a geographic region, different levels of descriptions of vegetation and processes are expected to be used to fit the nature of the issues being analyzed.

### 7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)

The initial object-oriented design identifies three landscape components, vegetative, terrestrial, and aquatic. However, the initial version of SIMPPLLE addresses only the existing vegetative component of landscapes. Current development plans involve adding both the terrestrial and aquatic elements. Long-term plans provide for extending the object-oriented design to include social elements of the landscape.

For the existing plant communities, structure, function and composition are all represented. As other elements are added to the system they will have parallel attributes of what is meaningful as structure, function and composition.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

Current conditions for the system have to come from two sources: vegetative attributes from data sources such as corporate data bases and spatial attributes from a GIS environment. Summarizations can be made of the initial conditions within SIMPPLLE, but it is expected that the user will use do most of this in the two environments which provided the data to begin with.

**9) Predict future conditions: Does the system predict future conditions and evaluate against Desired Future Conditions (DFC's)? What methods are available?**

Future conditions are simulated by using probabilities associated with the processes that drive the change. These can be used in a stochastic fashion, or the highest probabilities can always be used, or only the process of stand development can be used. Instances of the existing vegetative communities maintain all the changes in their state, the processes responsible, the probabilities, whether the process originated within the community or spread into it, and any hazard ratings for insects and diseases. A summary of the total landscape is made to assist in seeing how much of each process is occurring by time step (decades). Analysis of changes in states and comparisons to desired future conditions is achieved by exporting the data to other analysis systems, or updating the attributes in the GIS system that provided the initial spatial attributes.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Alternatives can be represented by schedules of treatments applied within a simulation. Changes in vegetative states and in the levels of processes can be compared across alternatives. Any social or economic interpretations would have to be made by exporting results to other systems.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

No. At this stage of development the output functions have not been coded into the user interface. Uses to date have been tailor-fit to packages such as Harvard Graphics, Fragstats, Grass, Panmap, and ArcView to provide graphic comparisons of alternatives.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

No.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

The GUI is designed to provide the user the means to change probabilities for processes, the magnitude of the change due to process interaction, and what resulting vegetative states are based on comparing simulation results with observed or "expected" behavior and/or documented research results.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

None exist at this time.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

SIMPPLLE has not been designed to function within a GIS environment. But spatial attributes from a GIS are necessary input requirements. These spatial attributes can take the form of either coordinates for polygons, row and column number for pixels that SIMPPLLE uses to determine adjacency; or a listing of what communities are adjacent as determined by the GIS.

Adjacency in the initial version is defined by what communities share a common boundary. However in future versions, adjacency can have different meanings for different functions and processes. Adja-

gency is a key attribute that is used in adjusting process probabilities and controlling spread of processes. Interpretation code can be written to include the consideration of adjacency when evaluating the changes in vegetative states within SIMPPLLE, or information on changes in states or processes can be passed back to the GIS environment to do the spatial analysis.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

See answer to #15.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

Levels of:

1. individual plant community
2. adjacent plant communities
3. within the landscape being analyzed
4. above the landscape being analyzed

Interactions across these scales influence the probabilities of processes occurring. The presence of conditions at these different scales can be used in interpretation of providing functions. For example the probability of a community having western spruce budworm starts with its within-community conditions. This is modified by the conditions of adjacent communities and what current and past processes have occurred. Further modification is made using attributes that describe "aggregates of suitable host communities" throughout the entire landscape and what percent of it they represent.

For the process that is a combination of cold weather injury and bark beetles, individual community attributes do not influence the probability of occurrence. Its occurrence is tied to a Regional attribute that represents the likelihood of a weather event that will produce the damage. When it occurs all susceptible communities within the landscape will sustain the process and its associated changes.

**18) Scale-appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

These differences can be supported in how SIMPPLLE is formulated for a specific type of analysis: whether very detailed or broad forest type descriptions are used; whether individual or aggregates of processes are used, and whether individual treatments or treatment regimes are designed.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

This is currently under analysis as SIMPPLLE is being used in the Bitterroot Ecosystem/Management Research Project. As we go from "landscapes" to "geographic" scales we will be evaluating the differences in vegetative descriptions and associated pathways be handled by aggregation or transformation.

## **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Version 1 of SIMPPLLE has been operational without a GUI for the Bitterroot Nation Forest. Input/Output linkages have been tailored to what the Forest has been using prior to their attaining the pieces under 615. We are currently near the final stages of a contract for an "initial" GUI.

**21) Current users: List existing successful applications and users**

Has been used in the Bitterroot Ecosystem/Management Project on the Bitterroot National Forest. Currently working to create formulations of Version 1 for the Nez Perce, Lolo, and Helena National Forests in Region One. Working with the Challis/Salmon NF in Region Four to provide an initial formulation.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

System is written in Common Lisp using structures built upon it by GoldHill Inc.'s "GoldWorks". It functions in both a PC and Unix environment. However the emphasis has been on delivery of a Unix version for the 615 hardware and software.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

Disk storage depends on the size of the landscape; the number of plant communities, the number of processes included, the number of treatments scheduled, and the number of decades projected. CPU and RAM depend on what one defines as an acceptable turnaround time for a simulation. It has been run on a 386 PC with as little as 8 megs and on a workstation with 64 megs.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

As it currently utilizes structures from GoldHill's GoldWorks a licensing of an "executable" for each site would run around \$200 to \$300. However future options can be to replace the GoldWorks portions with the Common Lisp Object System, or to rewrite the entire system in C++.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

None required.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Currently funded at an annual cost of approximately \$115,000 for 1 developer and associated support costs. These costs are shared between INT and Region One. It is projected that 3 years will be required to deliver a version of SIMPPLLE to Region One that includes the components of vegetation, terrestrial and aquatic elements. Seven different "formulations" will be delivered, one for each of seven assessment areas that the Region is divided into. This final development will include finalizing the GUI with I/O linkages specific to the Region's implementation of 615 technology.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

District silviculturists and foresters, Forest specialists and planners, and Regional specialists and planners

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

The system is agency independent. There has been interest by BLM and Potlatch Forest Industries.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

The system maintains a collection of class instances for all the vegetative communities and a summary of the total landscape. The input/output linkages are intended to be tailor-fit to transfer data between these instances and the other software systems a user has available.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis.**

The underlying object-oriented design was developed to provide the user flexibility in how the existing vegetative units (and future terrestrial and aquatic units) are described and where the data comes from. The specific formulation of a version of SIMPPLLE will depend on what the user sees as necessary to

address issues, can be supported by available inventory data, and is needed to be able to predict process probabilities.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Both.

**32) Incomplete data: Will the system run with incomplete data?**

The system needs information for each plant community. But the level of resolution can vary from in-place inventory data, photo interpreted data, and satellite imagery.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

The system has been developed to be independent of the data structures that are used to provide maximum flexibility (and at the start of development, 615 results were unknown). I/O functions will be written to access the FS corporate data structures.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

No visualization techniques are contained within SIMPPLE. The design of the system is to export data to whatever system is desired by the user. To date other software packages used for visualization and additional analysis have been: Harvard Graphics, Systat, IBM's Data Explorer, Grass, Panmap, Arc/Info, and Fragstat.

**35) Report generation: Describe the types of reports generated.**

Within SIMPPLE a class instance that represents the entire landscape is created to facilitate reporting of the acres of processes by time step and the origin and spread of processes. Additional code is planned to be developed to provide the user with a greater range of summary options within SIMPPLE, but for now the major report and analysis capabilities are obtained by exporting data to other systems. See answer to #34.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

See answers to #34 and 35. The object-oriented design does include a class for "interpretation" however limited use has been made of it to this time in development. One use has been a combination of what structural states provide suitable travel corridors for elk and the spatial requirements for them. These criteria are applied to the set of changing states to provide an interpretation of where travel corridors currently exist, where they are likely to be lost over time due to changes in the plant communities, and where there are opportunities to create new corridors.

Both the processes and the changes in states can be "accumulated" over a series of simulations to be used in identifying the probability that parts of the landscape will have a certain process or will provide a certain vegetative state. These are the types of interpretations that can be used to design alternatives to help meet desired future conditions.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

What may be fixed into a formulation of the system as defaults has to be agreed upon by the users/resource specialists in each area for which the formulation is to apply. For example what may be common throughout Region One in all formulations is a "method" to determine probability for the budworm process. But each formulation may have significantly different code within that method that best fits the combination of research results and experience. The knowledge of the relationship between vegetative states and processes becomes "fixed" for a formulation, but is developed by a core group of specialists for each area.

## User Support

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

None has been developed yet.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

None developed yet.

**40) Online support: Is there help available within the system?**

Not developed yet.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

An activity log is generated.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

These features have not been expanded upon yet. All necessary information to do so is maintained within the system.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

None has been developed yet.

## Performance

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

This depends on the complexity of the description used for the existing vegetation, the number of processes used, the number of plant communities within the landscape, and the number of treatments scheduled. For what could be considered a most complex situation with approximately 1500 plant communities, it has taken 3 to 4 minutes to simulate a 1 decade time step. We have commonly made 5 decade simulations so at most, 20 minutes.

For smaller landscapes used for demonstration or training purposes the execution time is so short I want to explore an interactive link to ArcView in the GUI so a user can see changes taking place in vegetative attributes, or the occurrence of processes as the simulation is being made.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

The answer depends on how one interprets "set up an application". If we mean to create a new formulation for an area; decide what level of vegetative description is appropriate, build vegetative pathways using these descriptions and a selected set of processes, capture the desired behavior of processes, their probability and spread, capture the level of management treatments, and then test performance and make modification; this could be between 1 and 2 months. If we already have a formulation and we are just extracting clean data to run a new landscape this could take one to two days. If the data has many errors, which tends to be common in many FS data bases, it could take up to a week.

Once we have all the data into SIMPPLLE, making changes such as with or without fire suppression; stochastic vs. highest probability vs. stand development only; making new treatment schedules or locking in processes takes only a few minutes.



## Computational Methods

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

Contains elements of deterministic, stochastic, simulation, knowledge-based, and expert systems.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

The system implicitly deals with 1 and 2 through the nature of its design. To address vegetative change at landscape scales over long time frames the awareness of items 1 and 2 should encourage one to look at systems that do not rely on modeling fine scale processes and require very detailed vegetative information. SIMPPLLE is designed to work with varying levels of descriptions for plant communities as "types". SIMPPLLE is designed with the approach of taking knowledge that may be generated through the use of fine scale models and capturing it in a different format, not trying to figure out how to directly apply a fine scale model at different scales.

The uncertainty and risk is approached by using probabilities for processes to make stochastic simulations. Processes and changes in states over numerous stochastic simulations can be accumulated. These can be used to describe the probability of achieving certain states and the probability for disturbance processes throughout the landscape. Both of these features are linked to the actual pattern of vegetation on a landscape.

Changes in vegetative states from a process may occur before a scheduled treatment can be applied, thus making the treatment infeasible. Infeasible treatments are defined within the system to help a user realize that some alternatives may not be fully implementable. The practicality of implementing alternatives within a dynamic landscape depends upon the impact they have on the probability of processes in both treated and adjacent communities.

**48) Identify particular system strengths that are not included in the above list of attributes.**

The ability to capture interaction between landscape components; not just the vegetative components that are in this initial version, but interactions between vegetative units, terrestrial units and aquatic units. Fine-scale models that may focus on each type of element separately may provide significant knowledge, but that knowledge has to be integrated at different scales to be useful to managers. SIMPPLLE provides a means to integrate knowledge generated by fine-scale modeling systems, research studies on processes of change, and expert experience.

# SNAP

**1) System/tool Name: Title or acronym of tool.**

SCHEDULING AND NETWORK ANALYSIS PROGRAM: "SNAP" II+ and III

**2) Brief description: Short statement of purpose and functions.**

SNAP is designed to assist in the scheduling and transportation planning for harvest areas. Using certain rules, it can schedule the harvest for up to 30 time periods considering costs, several species, alternative destinations, non-adjacency requirements, and transportation systems. SNAP attempts to either maximize present net worth or minimize discounted costs. SNAP combines pattern generation and network analysis to find feasible solutions— both of units that are selected for harvest and those that are not selected for harvest. Both even and uneven-aged management can be modeled.

In addition to normal non-adjacency rules, SNAP can aggregate units during pattern generation to form "super polygons" subject to maximum size of disturbance limits. Also units may be excluded from harvest and wildlife corridors may be created by connecting sets of polygons which conform to the eligible seral stages defined by the user. Two version are available: II+ is capable of doing 1,000 polygons with 3,000 links. SNAP III is capable of doing 5,000 polygons, 10,000 road links, 20,000 stream links, 50 time periods, 100 polygon attributes, and 250 seral stages.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

Dr J. Sessions and J.B. Sessions Oregon State University, Forest Engineering Department, Corvallis, OR 97331-5706, (503) 737-2818, FAX: (541) 737-4316, E-mail: john@sessions.cof.orst.edu

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

User needs to define the problems. One must describe the problem in terms of treatment activity polygons and with attributes describing the polygons related to the issues one wishes to analyze.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

This model was design to function at landscape and project scales; however, it is not limited to that scale. Model is not hierarchical.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

Independent of region/locale

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

User must translate these variable into SNAP input.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

The current or existing state prior to treatment can be displayed. This allows a basis of comparison when alternatives are analyzed through the model.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

Future states or condition of the area can be displayed up to 30-periods.

- 10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Alternatives are displayed in the form of thematic maps and network (roads and streams) maps and tables for each time period in the problem. Targets, objectives, habitats, and other attributes are explicitly displayed over time.

- 11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

One of key feature of SNAP is that alternatives are developed in "rapid time." It typically takes less than 5-minutes to solve a new alternative which facilitates public participation.

- 12) Consensus building capability: Is explicit consensus-building methodology included?**

System can provide information for consensus building, but it is not a consensus building model.

- 13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

Not an explicit feature of SNAP; however, it can provide information to other levels or scales.

- 14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

Presently, the model has the capability to generate outputs that are in a format useable by all major spreadsheets and relational databases (RDB). Currently there are no direct data links with other units built within the system.

## **Spatial Issues**

- 15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

SNAP can detect and display adjacencies and corridors and can optimized (close approximation by heuristic) on the basis of juxtaposition.

- 16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

SNAP displays and shows the effects of alternatives spatially and can optimize on polygon-to-polygon juxtaposition variables.

- 17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

N/A

- 18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately**

User must define within context of the input.

- 19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

N/A

## **Basic Development/Status**

- 20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Fully operational

**21) Current users: List existing successful applications and users.**

Forest Service ,Western USA, DNR, BLM, Private Forest Industry, etc.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

SNAP is written in Professional Pascal. It runs under DOS 6.2+ or newer.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

System Requirements SNAP II+ include a 386dx with at least 8-mb of memory, and a monitor with screen resolution of 800x600 or better. SNAP III requires 32-mb of memory, pentium 90 or better, 570 of 640k memory available.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

Other software: none

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

N/A

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Continued Program Development costs are approximately \$30,000 per year.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Project planner, Forest engineers, and Forest analysts.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

System is being used outside the Forest Service.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

SNAP requires coordinate information and resource information by logical management units (polygons), and a description of the existing and potential transportation system. FS presently uses ARC-INFO or LT-Plus to pass graphic data to SNAP. User provides attribute data by a series of tables.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

NO

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Both new and existing data can be utilized

**32) Incomplete data: Will the system run with incomplete data?**

System requires data for all units; however, data maybe at different resolutions.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

System imports data from corporate data structures. Transformation of data is required.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Thematic maps, network graphics, charts, tables, and overlays.

**35) Report generation: Describe the types of reports generated.**

Screen Capture and System reports available through use of a menu.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

N/A

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

N/A

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

2-day training session is available and given at least 2-3 times per year. Both Forest Service and OSU training available.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

Hot-line is available

**40) Online support: Is there help available within the system?**

N/A

**41) Self-documentation: Does the system keep an activity log and data lineage?**

Activity log but no data lineage

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

Manual and model Help function.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

User's Guide

## **Performance**

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

Usually less than 5 minutes. With SNAP III, 2,500 polygon problem takes from 3-5 minutes to solve per solution. Usually, 10 or more solutions are run.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

1 Week

## Computational Methods

**46) Modeling techniques:** List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.

Heuristic

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis:** Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?

N/A

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

1. Approximates MIP optimization without usually long solution time associated with MIP.
2. Results are graphic and tabular.
3. SNAP II+ can be done on a laptop computer
4. Conversion programs from ARC-INFO to SNAP exist.
5. Result can be both in English or Metric

# SPECTRUM

**1) System/tool Name: Title or acronym of tool.**

SPECTRUM

**2) Brief description: Short statement of purpose and functions.**

SPECTRUM is a linear programming-based model designed to schedule management treatments to achieve ecosystem management, financial, or other goals.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

Kathy Sleavin, Forest Service Ecosystem Management Group, 3825 E. Mulberry, Fort Collins, CO 80524  
(970)498-1833

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

Legal constraints, such as non-declining timber flow, are easily incorporated into a SPECTRUM model. Any NEPA constraints can be modeled in SPECTRUM.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

The system can be applied at any scale.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

Unlimited.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

Explicit

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

Yes. The model can summarize data and treatments for any time period including the present.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

Future conditions are projected based on the interaction of scheduled treatments and successional processes.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Users analyze alternatives separately. By downloading alternative solutions to data bases, alternatives can be easily compared. Multiple executions of a model can be run with small parameter changes made in each model to analyze alternatives.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

No

**12) Consensus building capability: Is explicit consensus-building methodology included?**

No.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

No.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

Yes, but the links are not specific.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

User can construct model to examine adjacency, but no explicit assistance is given.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

No. If users define data spatially, (e.g. by watershed or ranger district), model data and results can be displayed to the same spatial detail.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

Yes, can analyze at both stand and watershed level via zones.

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

No.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

Not applicable

## **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Operational

**21) Current users: List existing successful applications and users.**

Used on National Forests throughout the country, and by private industry throughout the world.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

Operates in MS-DOS.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

IBM compatible 80386 or better, internal math coprocessor, minimum of 8 MB RAM, hard disk with 200 MB free, mouse, C-whiz solver

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

C-WHIZ LP solver required. The FS currently has a site license for 200 copies of this software.



## User Support

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

Existing 4-day training sessions

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

Yes, any other type requested.

**40) Online support: Is there help available within the system?**

Yes

**41) Self-documentation: Does the system keep an activity log and data lineage?**

Yes. Activity log only.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

No.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

Excellent

## Performance

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

1 minute to 45 minutes, average is 8 minutes

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

To build a new model may take 1 week to several months. To modify an existing model may only take 5 minutes.

## Computational Methods

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

Simulation and optimization, deterministic

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

1) no. 2) no. 3) yes, explicitly. Probable vegetative changes due to wildfire, insects, disease, and other events can be incorporated into the model. 4) yes, by altering a coefficient(s) and re-running

# TEAMS

**1) System/tool Name: Title or acronym of tool.**

TEAMS (Terrestrial Ecosystem Analysis and Modeling System) — Menominee version.

**2) Brief description: Short statement of purpose and functions.**

The Menominee version of TEAMS is a hierarchical planning system designed to identify an optimal management path for moving a forest from current condition to desired future conditions (the "legacy forest"). At the strategic level it provides a schedule of forest-wide management activities by stratum for  $n$  periods of  $t$  years each (user-specified). It passes first-period results to the tactical level which assigns first-period treatments to strata within compartments on an annual basis.

Legacy forest goals incorporated in the model include: (1) ecologically appropriate cover types on each habitat type, (2) optimal structure (even- or all-aged) for each cover type, (3) regulation on optimal rotation age for even-aged cover types, and (4) cover type diversity within each habitat type and forest-wide. In addition, desired harvest acreage by period may be specified for each cover type and in total. The strategic model controls harvest flows on a period basis over the entire planning horizon and the tactical model controls harvest flows on an annual basis over the first period.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

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## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

The system does not handle NEPA explicitly. It provides flexibility to do so in that goals and allowable management activities may be specified by the user.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

The system was developed for use at the landscape level.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

TEAMS may be employed in any geographic region.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

The model is concerned only with achieving a desired future forest condition and output flows. Social, economic, and biophysical concerns are represented as goals which are externally developed by users.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

The model does not analyze current conditions.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

The system predicts future conditions and compares them to desired future conditions which are specified as legacy forest goals.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

The system is designed specifically to generate an array of management alternatives to allow comparisons of tradeoffs among alternatives. Tools are not provided to compare alternatives, however.

**11) Public participation: Are explicit functions available to display and test alternatives and tradeoffs?**

Outputs are currently not designed specifically for public participation. This capability may be added later.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

Consensus-building capability is not explicitly included.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

The model provides expected treatment results following each entry cycle. These could be employed for monitoring purposes.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

The model does not currently provide for information sharing.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

The Menominee version of TEAMS has no direct spatial analysis capabilities.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

The Menominee version of TEAMS has no direct spatial analysis capabilities.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

The Menominee version of TEAMS has no direct spatial analysis capabilities.

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

The Menominee version of TEAMS has no direct spatial analysis capabilities.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

The strata employed in the model are quite detailed and location-specific. Data are entered at the compartment level but aggregated across locations at the strategic level. At the tactical level, strategic results are allocated back to the compartment-specific strata. The strata where treatments are assigned can be easily located using the Menominee GIS but the linkage to GIS is currently manual.

## Basic Development/Status

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

The model is operational with respect to the specific needs of the Menominee Tribe and is currently being employed by them in forest plan development. It is not yet operational in the sense that it is ready for general distribution.

**21) Current users: List existing successful applications and users.**

TEAMS is currently being used by Menominee Tribal Enterprises in preparing a forest plan.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

The matrix generator (written in C++) and commercial optimizer (C-WHIZ, written in C) run under DOS on Intel platforms — used in conjunction with R-Base for DOS.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

Hardware requirements: 486/50MHz CPU, 16 MB RAM (for C-WHIZ; matrix generator needs only 640 K). Size of model determines memory disk requirements: At least 20 MB is recommended.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

Operating system is MC-DOS 6+. Commercial software: KETRON'S MIP III with C-WHIZ and Microrim's R:Base 4.5+.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

Not known.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Although we will continue development work on the model for the foreseeable future, we do not have estimates of the development time-frame nor future development costs.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Our plan is to ultimately design the system for non-sophisticated users (managers, planners, and ID teams).

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

The system is not agency-specific.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

I/O is in ASCII; Intermediate/internal data files are binary.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

The system is not capable of taking user-specified variables and formats.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

The system runs with generally available inventory data. However, users must include management information as part of the input database for each stratum. These include: desired structure (even- or all-aged), allowable management options, and optimal, minimum, and maximum rotation ages for even-aged cover types.

**32) Incomplete data: Will the system run with incomplete data?**

The system will not run with incomplete data.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Data are currently imported from the Menominee Arc/Info database to R-Base. TEAMS employs the R-Base files as input. Outputs are exported to R-Base for report generation.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

The user (Menominee Tribal Enterprises) utilizes model outputs to prepare reports and graphics.

**35) Report generation: Describe the types of reports generated.**

Tabular reports are generated that detail forest structure following each entry and at the end of the planning horizon. Also displayed is harvest activity occurring during each period.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

The system does not interpret outputs.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

Some coefficients may be defaulted but the user may specify all of them.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

We have not yet developed training sessions for TEAMS.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

We work on a continuing basis with the Menominee, our sole user at this time.

**40) Online support: Is there help available within the system?**

Ditto.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

The system does keep an activity log, detailing the parameters of each run.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

No explanation facility.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

User manuals have not yet been developed. Program is well-documented.

## Performance

### **44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

Strategic runs require less than 30 minutes. The tactical model runs in 3-4 hours.

### **45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

Most information required to run the model is in the database. Once the database has been perfected, new alternatives may be specified within a few minutes. This does not include the time required to analyze previous alternatives and to define new ones.

## Computational Methods

### **46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

Both the strategic and tactical models employ goal programming. The tactical model utilizes a mixed integer formulation.

### **47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

The model does not explicitly deal with risk and uncertainty associated with catastrophic events. However, it contains few assumptions. Determining the effects of treatments on cover type, structure, and age class is straightforward. The only assumption is that such treatments will be successful.

### **48) Identify strengths of particular systems that are not included in the above list of attributes.**

1. The TEAMS strategic model is designed to handle extremely complex forest situations over long planning horizons. It was developed and tested for a forest containing multiple cover types, multiple habitat types, and both even- and all-aged cover types. The planning horizon can be up to 200 years. Although the outcomes modeled are somewhat limited, the typical strategic GP matrix for the Menominee contains over 15,000 columns and more than 20,000 rows.
2. The architecture of the matrix generator is very flexible. It is almost entirely input-driven. Users may define strata using their choice of parameters and degree of resolution. They may also specify appropriate management alternatives and restrictions for each stratum individually. The matrix is then built row by row and column by column depending on the user-specified database. A new matrix can be generated within minutes whenever data or management specifications are updated in the database. Matrix dimensionality is determined entirely by input data, and is limited only by the capacity of the optimization software (32,763 rows, unlimited variables).

# Terra Vision

**1) System/tool Name: Title or acronym of tool.**

Terra Vision

**2) Brief description: Short statement of purpose and functions.**

Terra Vision is a new conceptual and technological approach to the design and function of natural resource management decision support systems. It results in positive, constructive changes in perspectives about land planning and land use decision-making by both landowners and interested constituencies.

Terra Vision is a comprehensive, generally applicable set of tools and approaches to support strategic planning and policy analysis for natural resource ecosystems to achieve both ecological and economic goals. It was crafted in 1995 to support the preparation of sustained yield plans for Louisiana-Pacific Corporation's 500,000 acres of timberland in California. Terra Vision is new technology that utilizes the best of contemporary computer, data management, GIS, and multimedia presentation technology.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

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## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

The system does not explicitly or automatically handle pre-defined NEPA issues. The user would have to define the problem and issue, and then for each subject problem, use the system to generate necessary information for NEPA documents. It has not yet been used to prepare a NEPA document, although it has ensured that ecological and economic requirements for sustained yield plans stated in the California Practice Rules are being met.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

Terra Vision is completely general concerning spatial scale. It can be used for ownerships, ecosystems, and landscapes that range from a few hundred acres to tens of millions of acres. In our current applications, we use planning units of about 300,000 acres, but explicitly recognize planning watersheds from 1,000 to 15,000 acres, and land types down to ten acres within them. Hierarchical planning can be used to aggregate the planning unit results to higher levels. The system is flexible and can accommodate data sets that are large-scale, high-resolution, and multi-attributed as well as those that are smaller in geographic scale and less detailed.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

Terra Vision has been designed to work anywhere in the world. It has been quantified for its initial applications for the redwood/Douglas fir, upland oak, and Sierran mixed-conifer ecosystems of California. Inventory data for any ecosystem can be accommodated; the FREIGHTS tree growth simulator is designed to develop treatment-response projections for all forest ecosystems. Local simulation or yield response models can be used or their tree growth model coefficients adapted to the FREIGHTS simulator and the various secondary ecological economic and social output simulators within Terra Vision (see Terra Vision: An Overview for more information).

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

Terra Vision can explicitly treat the structure, function, and composition of all social, economic, and biophysical elements that require quantification, projection, and tracking by the user. A necessary caveat is that inventory and base maps, and reasonable and acceptable simulation models, exist for making projections. For example, the present applications explicitly recognize current and future size, species, and density of forest vegetation in aggregate and in a mapped polygon-by-polygon basis. This information in turn is used to evaluate wildlife habitat, diversity, connectivity, and the dynamic spatial patterns of change in the vegetation mosaic over time. Snags and dead-and-down material are included in the inventory plots and hence allow tracking of these habitat elements. The activity pattern is projected over the landscape and, when evaluated against topography, soils, roads, and other land attributes, it is possible to project mass failures probabilities for each polygon. A variety of current demographic information can be included and updated in the spatial database, including land ownership, structures, developments, and population density. Terra Vision provides a flexible shell and data-management and analysis approach that allows the user to specify and include any data of interest. Terra Vision does not come with any pre-loaded inventory or other data; all data is input into the system by the user.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

Terra Vision can produce a tremendous range of assessments about the current conditions of a forest landscape from aggregate statistical summaries of commercial timber inventory and ecological seral stage structure to high-resolution spatial evaluations of habitat for a given species. The quality, accuracy, and detail of such assessments will of course depend on the detail and accuracy of the map and inventory data available. Terra Vision contains tools to assist the user in assessing the current resource conditions.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

Terra Vision makes explicit projections of future ecological, economic, and social conditions and presents them in aggregate statistical and mapped spatial formats. Generally, the resource capability model generates information about future forest outputs and conditions for every land type and prescription combination the user wishes to consider (for more information, see Terra Vision: An Overview). Through a combination of database, GIS, and mathematical programming analysis, a given land-use policy is translated to a table that assigns all the area in each land type to one or more prescriptions. Using algorithms implemented within the GIS, the prescriptions for each land type are assigned to the individual polygons of that land type. This gives the user the ability to spatially project future conditions. Policy models specify restrictions on spatial activity and desired future forest structures both in aggregate and by spatial subunits. These can be stated as constraints or goals. One of the strengths of Terra Vision is its ability to project and direct management to achieve desired future conditions.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Terra Vision uses a wide range of techniques that make it easier to compare the current and future outcomes of implementing different policy options. Each policy or alternative is represented by a statistical tracking of all forest inputs and outputs over time; these statistical trackings are generated by the mathematical program and the report writer. This data is presented using spreadsheet-type graphics, such as charts, graphs, and tables, for the planning unit as a whole and for each watershed or other sub-unit recognized in the aggregate planning model. Information on forest structure over time, inventory, harvest, and jobs can be presented in these graphical formats. Several different policies or alternatives can also be compared. Because the policy is also given an explicit spatial assignment, maps of current and future conditions for each policy can be generated. This allows rapid visual comparisons of what will be occurring within a specified geographic area under the different alternatives. Statistical summaries and graphs to quantify these differences can also be produced.



**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

Terra Vision was designed with the specific objective of increasing meaningful public participation by improving model credibility and by making policy options easy to formulate and evaluate. It does so by providing easy-to-understand graphic and map displays and by making real-time policy analysis easier to achieve.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

Terra Vision encourages and supports consensus building through the use of sequential real-time policy analysis. The strategy is to allow individuals representing different values and perspectives to gather around a table and collectively learn how the forest ecosystem in question responds to different policies for use. In a workshop setting, several alternatives can be run, allowing participants to search out reasonable consensus points. The policy model program allows participants to easily modify constraints and objectives to represent their ideas and values. The reporting system enables participants to quickly see how their policies affect the flow of outputs and conditions of the forest ecosystem in question.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

Terra Vision inputs monitoring information through updates in the basic inventory and map database. This would then be compared to projected conditions to see how hopes and intentions match reality. To the extent permitted by the scope and detail of new monitoring information, the original policies can be run and evaluated with the updated information on the new conditions of the forest.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

Terra Vision can accommodate a variety of distributed processing arrangements. It is designed as a sequential series of analytical steps, each joined by standard format input and output files. There is no reason that different steps could not occur at different locations.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

Terra Vision is specifically set up to display and analyze adjacencies and spatial relationships. The GIS presents maps and visual images of model results. Recognition of spatial policies for corridors, buffers, and sensitive areas of various kinds is achieved by spatially delineating and identifying these areas in the GIS as separate land types, assigning them to one or more prescriptions, and including them in the planning model as a package of constraints. Over time, we anticipate that assignment algorithms and spatial evaluation programs will evolve as ecological scientists come up with more specific and quantitative targets and rules regarding the desired dynamic pattern of structure, habitat, and activity.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

Terra Vision can generate, display, and evaluate alternative spatial patterns of activities. As discussed in (15), the results of each specific spatial assignment pattern can be displayed and comparatively evaluated.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

Terra Vision is well suited to support multi-scale applications. This can occur in two ways: (1) by explicitly recognizing watershed, political, or administrative geographic subunits within a planning unit as land type strata so that all decision variables and forest outputs are tracked by these subunits, and (2) aggregations higher than the individual planning-unit level are done by treating linear program solutions representing the alternatives for each planning unit as integer variables and creating an aggregate

model for a super-planning unit or landscape that consists of sets of feasible and implementable alternatives for each planning unit. This is also the way mixed ownerships within a landscape could be aggregated. Along with the statistical aggregation in a linear program environment, the map representation(s) for each planning unit alternative can be pieced together for each permutation to present aggregate landscape maps.

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

Terra Vision can recognize scale-appropriate support in a variety of ways. In initial applications, we have maintained detailed spatial resolution at the planning-unit level to make full use of the data and because the spatial wildlife habitat models need polygons mapped down to a few acres to provide accurate results. As much as possible, the generation of yields is customized to watersheds, but this depends on the density of inventory data plots and the number of land-type strata recognized. The more plots the better. Scale resolution also depends on whether the strategic results for a sub-area will be passed over to a small-area tactical planning model such as SNAP to do some of the spatial analysis and assignment work. We feel that a complete spatial assignment of the strategic plan is essential to reliably predict and evaluate future ecological conditions. Decisions about appropriate usage are the responsibility of the planning team.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

Terra Vision can either transform or aggregate data when moving up through a hierarchy of planning levels; the user decides. For example, much of the watershed analysis of hydrology, fisheries, and wildlife populations are entered into the GIS database, used for site-specific policy constraints, and then used (primarily) for reporting at the watershed level. This data can then be aggregated and passed up to the planning unit model as totals or averages for each planning unit. We would expect individual watersheds to be aggregated into higher levels if models were built specifically for large-landscape policy analysis.

## **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Operational for commercial forest ecosystems in California. Operational prototype for other commercial temperate and boreal forest ecosystems. Conceptual prototype for all other ecosystems.

**21) Current users: List existing successful applications and users.**

Louisiana-Pacific Corporation, Western Division—five sustained yield plans. Pacific Lumber Company—one sustained yield plan.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

Currently, the first computational phase of Terra Vision—that of creating land types that are the basic units tracked through the planning process—is accomplished using workstation Arc/Info, thus requiring a UNIX workstation supported by ESRI. All other computational phases currently require Intel 486/Pentium machines running Windows 3.1 or Windows 95. Various programming languages are used including: C++, Visual Basic, Microsoft Assembler, ESRI ARC Macro Language and ESRI Avenue. The most likely migration platform for future releases is Windows NT.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

Unix workstation requirements—64 MB RAM, 2 GB disk storage provide adequate capacity for forest-wide problem formulation. PC requirements—Intel Pentium, 64 MB RAM, 2 GB disk storage provide adequate capacity for forest-wide problem formulation.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

Current operating systems are Unix and DOS/Windows. Other software in addition to Terra Vision include: workstation Arc/Info (ESRI), ArcView (ESRI), and C-Whiz (Ketrion Management Sciences, Inc.). Commercial single seat licensing fees for this software if not already installed are about \$25,000. License fees for Terra Vision have not yet been established. The current vision is that there will be nominal initial fees to cover costs of shipping, installation, training, media, and documentation. License fees for Terra Vision software will then be charged as "Usage Fees" on a per-unit-area basis for the planning area.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

Maintenance fees for Terra Vision have not yet been established. The current vision is that there will be no maintenance fees—only "Usage Fees" assessed at the time plans are developed and the software is used.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

The bulk of the effort to make Terra Vision a commercially releasable product involves developing comprehensive user documentation and a training program. It is anticipated that these will be available in six to eight months. Meanwhile, support services are available from VESTRA Resources at standard rates.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Terra Vision is a sophisticated set of tools for accomplishing the relatively complex tasks associated with ecosystem planning. There are two distinct, interacting groups of target users for Terra Vision. The first group is the policy group, composed of executives, managers, interested members of the public, and policy makers, all of whom construct policies, evaluate their consequences, and eventually come to a consensus about what final policy or plan will be implemented. This group of users also has a strong role in defining critical basic parameters of the planning model, including the number and kinds of land types, the number and kinds of prescriptions, the list of forest outputs to be tracked in the models, and the time and budget allocated for model building and policy analysis. The second group is the skilled technical group, whose members interact with the policy group to define the basic parameters of the planning model and then analysis, develop the needed inventory, construct databases, build the resource capability model, and help the policy group to use the system.

The following is a brief description of the types of staffing we envision to be in the skilled technical group: Senior GIS Analyst—would have thorough knowledge of the structure and quality of existing databases, spatial analysis, and display tools. Planning Analyst—would know how to formulate complex planning problems to be solved using linear programming and would be familiar with computer analysis tools. Quantitative Ecologist—would have a central role in using FREIGHTS and other simulators to specify management scenarios (prescriptions), generate output response streams, and evaluate them for accuracy, reasonableness, and consistency. Resource Specialists—silviculturists, geomorphologists, wildlife biologists, fisheries biologists, economists, sociologists, landscape architects, and foresters. These specialists would have the ability to evaluate and communicate model results and implications from maps, charts, graphs, and tabular reports.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

Terra Vision has not yet been used by the USFS. It has been used to develop ecosystem plans for two large private timberland owners in California. The planning approach and software tools are designed to be generic and have widespread applicability.

## Inputs/Outputs

### **29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Data import and export is of primary importance in the Terra Vision analysis framework. The computational modules of Terra Vision are designed to exchange information using either an internal binary format or some appropriate ASCII exchange format. The following formats are used: Arc/Info coverages and grids and ESRI-supported related database formats (e.g., Oracle). ASCII interchange file for vegetation inventory information. Terra Vision binary ecosystem predictions (yields) file and ASCII exchange format. Linear program matrix binary input file (C-Whiz\*.act file) and ASCII MPS format. C-Whiz binary linear program solution file and ASCII interchange files. ArcView-compatible data files (e.g., xBASE, Oracle, ASCII).

### **30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

Terra Vision is a flexible system and absolutely requires user-specified input at various stages of analysis.

### **31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Terra Vision has no specific data requirements and will run with both existing and new data. The planning analysis dictates the data requirements.

### **32) Incomplete data: Will the system run with incomplete data?**

Terra Vision relies on the planning analysis team to specify the models and associated data requirements. All models and analyses specified require complete information.

### **33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Terra Vision will work directly with Arc/Info data and related Oracle tables. It will also import data from other sources using specified ASCII interchange files.

### **34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Terra Vision uses Arc/Info and ArcView as its primary mechanism for spatial analysis, mapping, and charting/graphing. Information can also be exported through standard interchange formats to other analysis and visualization packages.

### **35) Report generation: Describe the types of reports generated.**

Terra Vision uses the reporting tools available in Arc/Info and ArcView as well as additional external reporting tools, such as Microsoft Excel.

### **36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

All outputs from Terra Vision must be interpreted by the planning team.

### **37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

Terra Vision requires that the planning team specify models, model coefficients, and decision rules. The intention is that as new models are developed over time by the Terra Vision user community, they will become available.

## User Support

### **38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

A training program is currently under development for Terra Vision. The training program will consist of the following: self-guided, introductory tutorials and instructor-guided lectures and exercises.

### **39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

Formal support for Terra Vision has not yet been established. All support for Terra Vision is currently available through VESTRA Resources.

### **40) Online support: Is there help available within the system?**

Limited on-line documentation will be available, but currently is not. Terra Vision is designed to be run by a sophisticated analysis team.

### **41) Self-documentation: Does the system keep an activity log and data lineage?**

Terra Vision maintains a minimal amount of information that documents the location of data sets and other pertinent information that define a particular problem formulation. Presently, only the minimum amount of information required to recreate a particular problem formulation is maintained.

### **42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

No explanation facility is available for Terra Vision.

### **43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

Comprehensive documentation for Terra Vision is being developed.

## Performance

### **44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

Once a problem is set up and a resource capability model has been established (see Terra Vision: An Overview for more information), model alternatives can be run and initially evaluated in 3 to 6 hours.

### **45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

Terra Vision assumes that the information to be used in the planning analysis has been defined, quality checked, and deemed to be appropriate for use by the planning team. This includes all spatial databases, resource inventories, and predictive models and coefficients. Establishing the problem structure is the responsibility of the planning team and could take between 2 weeks and 2 months to establish, depending on the complexity of the planning problem and the number of issues to be addressed (see Terra Vision: An Overview for more information on defining the problem structure). Once a problem structure has been established, 1 to 3 weeks of effort are required to specify predictive models and coefficients, establish spatial analysis processing procedures, develop management regimes to be considered, and develop criteria for evaluating and reporting on model results.

Computationally, Terra Vision is very efficient. Detailed landscape-level planning alternatives can be computed in 1 to 2 days. Approximate time needed to compute and solve a planning alternative with a linear programming matrix of approximately 90,000 columns and 10,000 rows is as follows: Time to build the resource Capability Model (done once with few revisions per plan). Create spatially explicit land production units that results in approximately 50,000 polygons and 3,000 unique land types: 4-8 hours. Generate yields (forest ecosystem outputs) for approximately 100 alternative management regimes for each of 3,000 land types, each containing up to 30 inventory plots: 8-16 hours. This step is dependent on the number of resource inventory plots and management regimes to be processed. The

processing is designed to be distributed across multiple computers to reduce elapsed time. Generate a linear programming matrix that results in approximately 90,000 columns and 10,000 rows: 2-4 hours. Time to Evaluate a Single Policy Model or Alternative. Solve the linear programming matrix (90,000 columns and 10,000 rows): 0.75-1.5 hours. Spatially link answer to GIS for further analysis and visualization: 2-4 hours.

## **Computational Methods**

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

The modeling techniques currently included in Terra Vision are deterministic with some stochastic effects and optimization.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

Terra Vision does not include any facility for assessing these items. It is the responsibility of the planning team to make these determinations.

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

The Terra Vision planning approach and software tools are designed to handle a wide variety of planning problems. While many of the concepts used in Terra Vision are not new, the approach and software tools provide for computationally efficient processing. This results in the ability to formulate and evaluate realistic alternatives at the landscape-level in 4 to 6 hours. Terra Vision also provides the ability to view the results in a spatially explicit manner, allowing detailed evaluation of potential impacts for a given alternative. These capabilities allow the planning team to iteratively compute, solve, evaluate, and provide mitigation for anticipated impacts within the planning process.

# UPEST

**1) System/tool Name: Title or acronym of tool.**

UPEST

**2) Brief description: Short statement of purpose and functions.**

UPEST calculates forest insect and disease risks using quantitative models found in the literature. UPEST uses UTOOLS spatial databases for input. Program outputs can be visualized with UVIEW. The program was written to allow the fast evaluation of disease and insect risks over large landscapes as part of watershed analyses in the Blue Mountains province of eastern Oregon.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

Alan Ager, Umatilla National Forest, 2517 Hailey Ave. Pendleton OR. 97801. 541 278-3740

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

no

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

landscape

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

western US.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

explicitly.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

yes. program uses published pest risk models found in the scientific literature.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

no.

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Alternatives are analyzed separately.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

No. UPEST outputs can be displayed with UVIEW.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

no

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

no

- 14) **Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

No.

## **Spatial Issues**

- 15) **Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

Some spatial relationships are used in some pest models and the program calculates them with spatial algorithms.

- 16) **Spatial alternatives: Does the system display or analyze alternatives spatially?**

UPEST output is spatial, and can be used to evaluate alternatives spatially with other programs like UTOOLS.

- 17) **Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

no.

- 18) **Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

no.

- 19) **Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

neither.

## **Basic Development/Status**

- 20) **Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Operational in the Blue Mountains for two years. Approximately three million acres analyzed at one-acre resolution.

- 21) **Current users: List existing successful applications and users.**

About 10 watershed analyses in the Blue Mountains.

- 22) **Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

Written and compiled in Borland Pascal with Paradox database engine.

- 23) **Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

386/33, 4 mb ram, 100 mb hard drive for small project area [5000 acres].

- 24) **Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

UPEST runs in DOS. UTOOLS programs are needed to build input databases. Borland Paradox is required for reports.

- 25) **Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

\$0.00



**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

no development planned.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

data are set up by GIS or analysts assigned to projects like watershed analysis.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

outside too.

## Inputs/Outputs

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

UPEST uses UTOOLS databases for input, and UTOOLS can import data from a wide variety of formats.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

yes.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

existing.

**32) Incomplete data: Will the system run with incomplete data?**

the program searches the input data for required data for each of the 20 pest risk models, if data are missing for a particular model it is not calculated.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

import/export

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

data are graphed in paradox, or mapped with UTOOLS/UVIEW.

**35) Report generation: Describe the types of reports generated.**

acres in each pest risk category for each pest risk model.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

no, pathologist/entomologist does interpretation.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

fixed.

## User Support

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

no training offered. Program can be run if user knows utools.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

Author provides support via phone.

**40) Online support: Is there help available within the system?**

no.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

no.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

no.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

Users manual is distributed with software.

## **Performance**

**44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

5 minutes.

**45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

2-4 days.

## **Computational Methods**

**46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

deterministic.

**47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

no.

**48) Identify strengths of particular systems that are not included in the above list of attributes.**

none.

# UTOOLS

**1) System/tool Name: Title or acronym of tool.**

UTOOLS/UVIEW

**2) Brief description: Short statement of purpose and functions.**

UTOOLS is a collection of programs designed to integrate a variety of spatial data in a way that allows versatile spatial analysis and visualization at the landscape scale. Applications include watershed analysis, fire recovery planning, wildlife habitat analysis, and landscape visualization.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

Alan Ager, Umatilla NF, 2517 Hailley Ave. Pendleton Oregon 97801, Robert Mcgaughey, PNW Research Station, Cooperative Forest Systems Engineering, College of Forest Resources, Univ. WA. Seattle WA, 98195.

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

User defines analysis problem.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

Designed for landscape/watershed scale.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

UTOOLS/UVIEW does not restrict the user to performing analysis within a specific geographic region. The system is very flexible in both the types of data that can be used for analyses and the types of analyses that can be performed.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

The treatment of individual elements is determined by the analysis needs of the user. UTOOLS/UVIEW provides a framework within which elements can be explicitly or implicitly treated as needed.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

Future conditions can be assessed using a variety of tools within the package and others for which data links are provided. In particular, the UVIEW program can be used to generate realistic images depicting future conditions based on analysis results. UTOOLS/UVIEW provides a framework to compare Desired Future Conditions with projected conditions but does not perform this analysis automatically.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

Yes, by same process as # 8

**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Alternatives are analyzed separately and elements addressed explicitly.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

The UVIEW program provides state-of-the-art visualization capabilities to display vegetation changes on a landscape scale resulting for management for natural disturbances.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

No explicit methodology is included in UTOOLS/UVIEW, however, the visualization capabilities in UVIEW provide a powerful method to communicate alternatives and facilitate the consensus-building process.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

No.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

Yes.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

UTOOLS/UVIEW contains a library of spatial analysis tools built specifically to address ecosystem management issues and data export/import capabilities exist to transfer UTOOLS databases to and from other analysis systems for these analyses.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

There are no data transformations among spatial scales.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

No.

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

No.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

Not sure of question.

## **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

UTOOLS/UVIEW has been operational for 5 years.

**21) Current users: List existing successful applications and users.**

Over 200 past and present users. Successful applications include watershed analyses, EISs, EAs, Forest Plan amendments, fire recovery projects, operational fire planning, President's forest plan development and implementation, research applications in logging systems, wildlife, wildlife habitat modeling, silvicultural planning, genetics, and aquatic assessments. User include state, federal, private, academic institutions in the US and other countries.

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

UTOOLS/UVIEW operates on PCs running MS-DOS, Windows 95, and Windows NT operating systems. The system is programmed in PASCAL and C and utilizes Borland's PARADOX database engine to create and access PARADOX database files.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

UTOOLS/UVIEW requires at least a 486/66 CPU with 4Mb RAM. Typical projects, i.e. 30,000 to 100,000 acres, require 500 Mb for disk space.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

UTOOLS/UVIEW operates under MS-DOS, Windows 3.1, Windows 95, or Windows NT. Analysis requires PARADOX for DOS or PARADOX for windows.

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

None

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

None...the system is fully developed and modifications and enhancements are not user-supported.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Users range from district biologists to regional analysts in the Forest Service. Data setup is performed by the users who retrieve the data from corporate GIS databases and other sources.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

It is not Forest Service specific, and is used by a variety of other state, private and non-profit groups.

## **Inputs/Outputs**

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

UTOOLS/UVIEW accepts most popular data formats used within the Forest Service. Specifically, UTOOLS imports MOSS import/export files produced by MOSS, ARC-INFO, or other GIS systems, ERDAS GIS files, USGS DEMs, ASCII flat-files, and database files produced by Dbase, Rbase, and other DMBS.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

UTOOLS uses PARADOX which can accept data in many user-specified formats. The system cannot process polygon or vector data in formats other than MOSS import/export format.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

Existing data.

**32) Incomplete data: Will the system run with incomplete data?**

It gives an incomplete answer.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

UTOOLS/UVIEW will operate with corporate data directly using Borland's SQL link to Oracle, however, performance issues may dictate the need to export data from the corporate environment for direct use in UTOOLS/UVIEW.

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

For standard "business graphics", UTOOLS/UVIEW relies on the graphing capabilities of PARADOX. UVIEW provides plan and perspective visualization capabilities that incorporate database queries to drape attributes on rendered landscapes. Landscapes can be viewed from any perspective, with or without vegetation cover. Many types of vegetation can be modeled including multi-story stands, snags, shrubs, and herbaceous cover providing realistic images of forested landscapes.

**35) Report generation: Describe the types of reports generated.**

Tabular reports can be prepared from UTOOLS spatial databases via PARADOX and related report generation tools.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

No.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

All analysis methods and coefficients are user-specified.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

Region 6 provides 3-day training sessions for interested users. Most users learn the system on their own in a few days. Distribution package includes a series of tutorial exercises and example data.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

The developers provide support via phone or email.

**40) Online support: Is there help available within the system?**

Online materials include a 70-page manual, help files, and a series of tutorial exercises.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

No.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

No

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

The documentation has been through many revisions to address the information needs of the users. The current documentation seems to be adequate for most users. Specific analysis methods are described and many useful examples are provided.

## Performance

### **44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

The run times for UTOOLS are highly variable depending on the analysis application. Some analyses may take an hour while others may take over a year depending on the analysis task and project time frame.

### **45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

For a typical watershed analysis, which might have about 200,000 pixels and 50,000 fields of data, it takes about a week to create the databases. Projects with very focused objectives like quantifying landscape structure for wildlife habitat assessment might take an hour or two from start to finish.

## Computational Methods

### **46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

The system does not use models *per se*...it provides a framework for users to define and conduct analyses using appropriate techniques.

### **47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

No.

### **48) Identify strengths of particular systems that are not included in the above list of attributes.**

The strengths are:

- 1) The software is all public domain and therefore free to all users.
- 2) Complex GIS functions can be completed easily without extensive training in the use of high-end, corporate GIS systems.
- 3) Spatial databases are an efficient framework for conducting ecosystem analyses.
- 4) Visualization capabilities allow users to evaluate the results of analysis activities using realistic portrayals of landscape conditions over time.

# WOODSTOCK

**1) System/tool Name: Title or acronym of tool.**

Woodstock Forest Modeling System

**2) Brief description: Short statement of purpose and functions.**

Modeling system for building harvest scheduling, vegetation management and ecosystem models; models can be simple inventory projections (with or without binary search), Monte Carlo simulations or generalized Model II linear programs.

**3) Developer/Contact: Name, Organizational unit, address, phone.**

Remsoft Inc., 620 George Street, Suite 5, Fredericton, New Brunswick, CANADA E3B 1K3  
voice: (506) 450-1511 fax: (506) 459-7290 email: remsoft@nbnet.nb.ca

## Scope and Capabilities

**4) Questions, issues, measures / NEPA Criteria: Does the system address NEPA issues explicitly or does the user need to define analyses and problems? If yes, elaborate how.**

If the user wishes to formulate constraints or limits that reflect NEPA requirements, they can do so, but the system is not designed with any particular agency's requirements in mind.

**5) Spatial scale / areal extent: Is the system designed for a specific scale (stand, landscape, region)? What potential is there for using the system at different scales?**

Woodstock was designed to be inherently flexible, and there are no built-in assumptions about area or units employed in output calculations. Therefore it should work (and has) on problems ranging from individual deer yards up to forests with over 100,000 ha of land.

**6) Geographic region applicability: In what areas will it work? Is it limited without major modification?**

Woodstock was designed to be inherently flexible, and there are no built-in assumptions about forest types or classification schemes - these are defined by the user. Currently, Woodstock is being used in Australia, in the southeast and northeast U.S. and in five provinces in Canada. The range of applications include very different forest types, land ownership and objectives.

**7) Social/economic/biophysical analyses: Are structure, function, and composition of social, economic, and biophysical elements explicitly or implicitly treated? Is the system specific to particular elements? (Please provide examples or choices.)**

I really don't understand what this question is asking. Woodstock was designed to be inherently flexible, and there are no built-in assumptions about area, units employed in output calculations or the types of outputs generated. These are all defined by the user. The user can choose whether to recognize elements implicitly or explicitly by his or her choice of yield components, outputs defined and the set of constraints imposed on the problem.

**8) Analyze current conditions: Does the system produce assessments of current conditions? What forms of analysis are used?**

Woodstock is essentially an inventory projection model and can report on forest conditions in each planning period. Forest conditions are user defined outputs and may be based on any user-provided yield component. Reports can also include summary operators for running totals, averages, etc.. Woodstock directly outputs to Lotus spreadsheet files which can be used for further analysis.

**9) Predict future conditions: Does the system predict future conditions to evaluate against Desired Future Conditions (DFC's)? What methods are available?**

Woodstock simulation models allow the user to specify output targets which presumably reflect desired future conditions. LP models can be formulated similarly using the objective function and constraints.



**10) Alternative comparisons: Are there explicit means to structure the analysis of alternative outcomes (including social and economic factors), or are users required to analyze alternatives separately? Which elements are addressed explicitly?**

Woodstock models can incorporate stochastic elements to assess variations in future outcomes due to uncertainty. For example, transitions from one forest type to another can be modeled as Monte Carlo events with given probabilities for each transition. Or, the selection of development types for a particular action can have associated probabilities of occurrence. Linear programming models can be formulated with multiple objective functions which are solved sequentially. In this type of benchmarking exercise, you can determine a range of outputs under a common set of constraints.

**11) Public participation: Are explicit functions available to display and test alternatives and trade-offs?**

Woodstock offers a wide range of user-defined and internal reports, as well as run-time graphs to display changes in outputs over time. Although Woodstock models are usually run as batch processes, the Woodstock editor lets you make changes in the input files directly and run the interpreter from the editor. Alternatively, your Woodstock models can be set up with interactive prompts for setting model parameters: for public participation, the interaction and run-time graphics make it easy for users to visualize the impacts of changes in things like silvicultural budget, harvest levels, etc.

**12) Consensus building capability: Is explicit consensus-building methodology included?**

Woodstock has been successfully used in small adaptive management workshops where participants learn the model syntax together and cooperate as a group to develop a model which reflects the group consensus. However, the software itself has no explicit functions that address this issue.

**13) Monitoring and feedback: Are there explicit functions that assist people in learning from monitoring efforts by comparing feedback to expected values?**

Run-time graphics can be used to track outputs. Up to 10 separate graph windows can be defined, and these graph windows can display outputs as line graphs or histograms. As the model runs, the user gets immediate feedback on changes in a variety of forest conditions, ranging from harvest level, to acres of suitable habitat to age class distribution.

**14) Distributed processing: Does the system have the capability to share information and facilitate decision processes with other systems at other locations?**

Remsoft is developing a blocking/scheduling tool that works in conjunction with Woodstock to produce spatially feasible harvest schedules. We are also cooperating with ESRI Canada to implement better linkages with ArcView and ArcForest. Woodstock is an Intel platform product that works under DOS, Windows95 and Windows NT and there are no plans to port to other platforms.

## **Spatial Issues**

**15) Analytical / spatial relationships: Can the system analyze or display adjacencies? Are there other spatial relationships (e.g., corridor analysis, fragmentation, habitat relationships) that are analyzed in terms relevant to ecosystem questions? How?**

Woodstock uses spatial information only in a gross sense: you can constrain activities within certain portions of the forest, but it does not address the spatial relationships listed. The Stanley blocking/scheduling tool we are developing does use adjacency and proximity relationships to schedule harvesting under opening size and adjacency constraints. This tool has been used by companies in New Brunswick for maintaining deer wintering areas.

**16) Spatial alternatives: Does the system display or analyze alternatives spatially?**

No. However, Woodstock models can be easily linked to GIS databases such as ArcView that can generate maps representing "potential impact areas". Stanley solutions can be directly mapped using ArcView.

**17) Multiscale interactions: Does the model or system use explicit hierarchical functionality on multiscale questions? How does it treat interactions across levels? What levels? (Please provide examples or choices.)**

Woodstock and Stanley use a hierarchical approach to forest management planning based on the work of Jamnick and Walters (1993). Woodstock is used as a strategic planning tool with a relatively long planning horizon. Stanley is a tactical planning tool that uses the initial periods of the Woodstock solution to guide the blocking and scheduling process — only the development types targeted by Woodstock

are eligible for blocking/scheduling. Cogswell (1995) demonstrated that this approach is sustainable over a rolling planning horizon because the subsequent re-planting exercises correct for prior over/undercutting.

**18) Scale appropriate support: Does the system recognize differences among prescriptive, allocative, and policy decisions that need to be supported at different scales and provide advice appropriately?**

I'm assuming this question is aimed at knowledge based systems and thus this question is not applicable to a discussion of Woodstock.

**19) Spatial resolution / aggregation: Are data transformed at different levels or simply aggregated or disaggregated?**

Woodstock is generally used for a single level of analysis at a time. Aggregation of stands to form stand types is really the only practical method of modeling large forest areas. However, Woodstock models can be purely stratum-based, area-based or mix of the two. Woodstock has been used to model small tracts of land (deer yards) where individual stands are represented.

## **Basic Development/Status**

**20) Current status: What is the current status of the system (conceptual, prototype, operational prototype, partially operational, fully operational)?**

Woodstock is commercially available. Stanley is an operational prototype.

**21) Current users: List existing successful applications and users.**

E.B. Eddy Ltd. - forest products company, wood supply analysis  
Champion International Corp. - forest products company, wood supply analysis  
Weldwood of Canada Ltd. - forest products company, wood supply analysis  
Daishowa (Canada) Ltd. - forest products company, wood supply analysis  
New Brunswick Dept of Natural Resources - provincial land agency, timber supply, wildlife habitat  
Alberta Dept of Environmental Protection - provincial land agency, timber supply  
Parks Canada - Terra Nova National Park, harvest allocation  
Parks Canada - Banff National Park, vegetation management planning  
Natural Resources Canada - Canadian Forest Service, economic timber supply  
Forestry Corp. Ltd. - consulting firm, wood supply analysis  
Seven Islands Land Co. - forest land management firm, wood supply analysis  
University of New Brunswick - Faculty of Forestry and Environmental Management, teaching and research

**22) Transportability: What is the across-platform portability, i.e. ease of moving between hardware and operating systems? (Specify languages and operating systems.)**

Woodstock is an Intel platform program (DOS, Windows 95 and Windows NT). There are no plans for porting to other platforms.

**23) Hardware requirements: What are the minimum CPU, RAM, and disk storage needed for program and data?**

Minimum: 386 processor, 4MB RAM, 2MB disk space, graphics adapter. Recommended: fast 486 or Pentium class processor, 8-16MB RAM, 100MB disk space, high resolution graphics adapter. C-Whiz LP solver recommended for LP analysis.

**24) Software requirements and costs: What is the operating system? Is any outside software needed to run the tool, such as compilers, libraries, other applications? (Include price estimates for the tool and other required software.)**

Woodstock is an Intel platform program (DOS, Windows 95 and Windows NT). Price: \$1995.00 To solve LP models, you need a third party solver which is not included in the Woodstock package. Remsoft has an agreement with Ketron that allows purchasers of Woodstock to obtain C-Whiz at a 20% discount (\$1200).

**25) Maintenance costs: What are the maintenance costs for support or license requirements on an annual basis?**

One year of support is included in the purchase price. Upgrades or fixes to the Woodstock code within one year of purchase are free. There are no annual license fees. Service contracts are available to interested clients and are worked out on an individual basis.

**26) Additional development and enhancement costs: What are the projections of annual expenses and duration of effort to complete planned development efforts?**

Woodstock is currently at Version 1.1. Work on additions and new capabilities is ongoing using in-house Research and Development (R&D) funds. These new capabilities will be available (when completed) in the form of optional, add-on modules.

**27) Target user: Who will actually run the system? Who needs to be involved in setting up data? List the organizations and levels applicable.**

Typically, Woodstock is used by a planning forester (or a team of planning foresters) in conjunction with a GIS manager and other advising specialists.

**28) Agency independence: Can the system be used outside the National Forest System, or is it specific to the Forest Service?**

Woodstock was designed to be inherently flexible, and there are no built-in assumptions that would make the software specific to any particular application or agency. Currently, Woodstock is being used in Australia, in the southeast and northeast U.S. and in five provinces in Canada. The agencies using Woodstock represent large forest companies, Federal and Provincial natural resources agencies, forest consulting firms and educational institutions.

## **Inputs/Outputs**

**29) Import/Export functions: List data formats that can be imported or exported, including reports.**

Woodstock input files are simple ASCII text files. User defined reports can be generated in ASCII text or WK1 spreadsheet format. System provided reports may be in ASCII text, spreadsheet or DBF format.

**30) User-designed inputs: Is the system capable of taking user-specified variables and formats to data input for analysis?**

Input files are keyword driven and space delimited rather than row/column delimited. The Woodstock interpreter is not case sensitive and therefore, the interpreter can accept a variety of formatting conventions such as tabbing, upper case/lower case, etc. The input file structure is designed to minimize redundant data entry.

**31) Data requirements: Does the system run with existing (traditionally collected) data sets, or is new field data required? Answer only existing data, new data, or both.**

I don't know what you mean by this. We have successfully converted other models to Woodstock format but in doing so you are also importing the limitations of the previous model. Obviously, if you wish to implement features in Woodstock that were not available in another model, it is likely that you will need to provide new data. Otherwise, Woodstock has no specific requirements for data other than what is necessary to represent your problem adequately (i.e. you can't estimate allowable cuts without data on forest area or growth and yield).

**32) Incomplete data: Will the system run with incomplete data?**

Again, I don't know exactly what you mean by this. Woodstock has a fairly sophisticated error checking facility to catch problems with incomplete data: for example, if you define an output based on an action that has not yet been defined, then the interpreter will flag the error. On the other hand, you could construct a vegetation management model that has no yield tables associated with it at all and the model would work.

**33) Agency corporate data: Will the system work with corporate data structures (Arc/Info and Oracle)? Does it run directly or import and export data to/from corporate data bases?**

Remsoft is developing a blocking/scheduling tool that works in conjunction with Woodstock to produce spatially feasible harvest schedules. We are also cooperating with ESRI Canada to implement better linkages with ArcView and ArcForest. Woodstock generates some reports in DBF format that can be read by a variety of Intel platform database managers (Access, FoxPro, dBASE, Paradox).

**34) Visualization techniques: What graphical outputs are included, e.g., graphs, charts, maps, exports, or visualization displays?**

Run-time graphics can be used to track outputs. Up to 10 separate graph windows can be defined, and these graph windows can display outputs as line graphs or histograms. As the model runs, the user gets immediate feedback on changes in a variety of forest conditions, ranging from harvest level, to acres of

suitable habitat to age class distribution. You can print graphs on one of several supported printers, or you can save the graph as a GIF file for inclusion in reports.

**35) Report generation: Describe the types of reports generated.**

Any output defined by the user can be included in user-defined reports. Outputs can be tracked in single periods, ranges of periods or all planning periods. Summary operators can be applied to outputs. User-defined outputs can be written in ASCII text or WK1 spreadsheet format. Woodstock also offers internal reports which are designed to aid in debugging and testing model prototypes. You can trace actions and transitions to verify your forest dynamics are working properly. You can generate age class reports to track changes in the age class distribution over time. You can report on which development types are eligible for actions (or ineligible for them). These reports are either ASCII text or DBF formatted files.

**36) Output interpretation: Does the system interpret outputs? Describe types of interpretations.**

No. Woodstock was designed to facilitate interpretation by providing a wide range of reports that the analyst can choose from. The analyst is not encumbered by data overkill or a lack of information and thus he or she can use professional judgment to make sound management decisions.

**37) Default coefficients and knowledge bases: Are there coefficients or knowledge bases fixed into the system, do they need to be calibrated from data inputs or by the user, or can the user choose between these methods?**

All aspects of a Woodstock model are user-defined. The only inherent capabilities provided by the interpreter are the ability to take inventories of yield components and to age development types. All other actions must be defined by the user.

## **User Support**

**38) Training needs and availability: How long are training sessions? Do they exist? How much self-training is feasible?**

Training sessions are arranged specifically for the client's needs. Some users are new to forest planning and require training in conceptual modeling in addition to that for teaching Woodstock syntax. Other users are quite adept and need minimal training and only occasional technical support. One client required a training session that encompassed five-days on-site; another user in Australia has had no formal training other than some quick questions via email and his models are very sophisticated economic timber supply analyses.

**39) User support availability: Is hot-line telephone support available? What other forms of direct user support are available?**

A toll-free number is available for support. Users may reach support staff via email (remsoft@nbnet.nb.ca) or they may fax written questions. Remsoft also has a WWW page where patches, tech tips and white papers will be available after March 1, 1996 (<http://www.remsoft.com>).

**40) Online support: Is there help available within the system?**

The Woodstock interpreter is essentially a batch program, and so an interactive help system is of limited value. However, the documentation includes separate Getting Started, Modeling Reference and User's Guide manuals. A complete set of well-documented, example problems is also provided with the software.

**41) Self-documentation: Does the system keep an activity log and data lineage?**

The Woodstock interpreter generates an error log where fatal errors and warning messages are written during processing. An image file can be generated which strips out comments and blank spaces from input files, substitutes values for global variables and decodes FOR..ENDFOR loops into the actual values used in the model. This file indicates exactly what information the interpreter used in processing your model.

**42) Explanation facility: Does the system provide references and explanations? (This question is most applicable to knowledge-based systems.)**

N/A.

**43) Documentation: Evaluate the quality and completeness of user manuals and support documentation.**

Remsoft has invested a great deal of effort to provide comprehensive documentation of the Woodstock Forest Modeling System that is attractive, easy to read and understand, and helpful.

## Performance

### **44) Time to run alternatives: How long do typical analyses take to run for typical applications? Is there a range of run-times for typical applications?**

The time required to process a Woodstock model depends on the size and complexity of the model. For example, one of our sample problems represents a forest with 111 development types, 3 silvicultural actions and 20 planning periods. A model that employs a binary search inventory projection method converged to a solution after 17 iterations and required 35 seconds on a 133 MHz Pentium machine running Windows 95. The same problem formulated as a generalized Model II LP took about 1 minute to generate the matrix (3,301 rows, 21,708 columns and 157,734 non-zero elements).

### **45) Time to set up application: How long does it take to generate or set up a typical set of data for a particular case (hours, days, or weeks)? With clean data to start or if data needs modification?**

A simple Woodstock model can be set up within minutes. Provided that growth and yield data is available, most users with no prior knowledge of Woodstock are able to have a fairly sophisticated working model within 3 or 4 days.

## Computational Methods

### **46) Modeling techniques: List modeling methodology used in system, e.g., deterministic or stochastic simulation, optimization, inductive reasoning, fuzzy logic, knowledge-based, or symbolic reasoning.**

Woodstock models can be deterministic or stochastic. Deterministic models include simple inventory projection, binary search and generalized Model II LP. Stochastic models are Monte Carlo simulations.

### **47) Uncertainty, accuracy assessment / error propagation / sensitivity analysis: Does the system explicitly deal with (1) accuracy of estimates, (2) the ways errors are propagated through time and space, (3) uncertainty and risk, or (4) sensitivity analysis? How?**

The Woodstock interpreter offers several means of facilitating sensitivity analysis. In a Monte Carlo simulation, multiple runs can be graphed on the same screen to indicate variations in outcomes. For example, suppose you have determined a superior harvest schedule using deterministic methods but you are concerned that the harvest levels may not be sustainable if random variations in outcomes take place. You can quickly convert your Woodstock model to a Monte Carlo simulation, and observe the success rate for maintaining the harvest level in a large number of simulations. By adjusting the harvest level, you should be able to arrive at an expected harvest level that matches your level of risk. In an LP model, the shadow price information associated with initial area constraints and user-specified constraints is saved in an ASCII text file. The decision variables, solution values and reduced costs of the optimal solution are stored in a DBF file.

### **48) Identify strengths of particular systems that are not included in the above list of attributes.**

Woodstock was developed specifically for the Intel PC platform - it is not a port of old mainframe or minicomputer FORTRAN code. The software was developed using modern object-oriented design concepts and is very parsimonious with memory. Thus, large scale models that require a workstation using other systems can easily be addressed with affordable PC technology. Furthermore, Woodstock uses common data formats that facilitate analysis with off-the-shelf business software like spreadsheets and database managers. Finally, the ability to formulate different models with just a few minor editing changes makes Woodstock unique among large-scale forest modeling systems - most comparable software employs either LP or simulation, not both.

Literature cited: Cogswell, A. 1995. Evaluating the spatial feasibility of future timber harvest allocations using a repeated planning process. B.Sc.F. thesis. University of New Brunswick.

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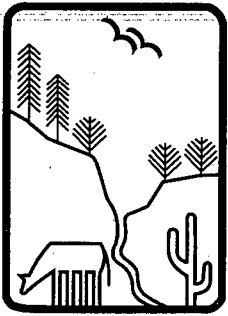
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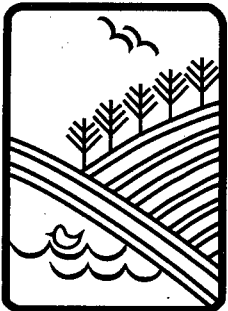
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## Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of seven regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

### RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

### RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

Albuquerque, New Mexico  
Flagstaff, Arizona  
Fort Collins, Colorado\*  
Laramie, Wyoming  
Lincoln, Nebraska  
Rapid City, South Dakota

\*Station Headquarters: 240 W. Prospect Rd., Fort Collins, CO 80526