USDA Forest Service

An Evaluation of

LANDSCAPE DYNAMIC SIMULATION MODELS

APRIL 2003

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1 Executive Summary

The Forest Service's Inventory and Monitoring Institute convened a panel of experts to evaluate three Landscape Dynamic Simulation Models (LDSM's) currently being used by National Forests as they revise their Forest Plans; VDDT/TELSA, SIMPPLLE and RMLANDS. The models are a hybrid of vegetation simulation models and Geographic Information Systems. The purpose of the review was to provide information to forest planners about the capabilities of the models and to respond to a request for information relative to policy development from the Washington Office Director for Ecosystem Management Coordination.

The models were evaluated on four characteristics: state space, memory, approach to landscape dynamics and approach to spatial characteristics and relationships. The panel identified the strengths of each model; VDDT with it's flexibility and open structure; SIMPPLLE with it's relatively sophisticated state space and ecological resolution and RMLANDS with it's high spatial resolution and elaborate spatial processes. All three models have the potential to estimate the effects of wildfire, insect and disease outbreaks, and vegetation management activities on wildlife habitat, vegetation composition, fire hazard potential, scenery and landscape patterns. According to the panel, the major weaknesses of each model were: VDDT for being less scientifically and analytically rigorous in depicting landscape relationships and for requiring TELSA to conduct any spatial analysis; SIMPPLLE and RMLANDS for the lack of a user-friendly Graphical User Interface (GUI) that allows new users to build a model without significant assistance from the developers and; RMLANDS for needing more initial developer support than SIMPPLLE and being more computationally intensive. The review panel could not reach any consensus on which of the three models were preferable for Forest Planning analysis.

Recommendations from the review panel are presented for future use and development of LDSM's. The report concludes with a discussion of the implications for policy development from the review. The report was reviewed for factual integrity by the model developers before final distribution.

2 Introduction

Forest Planning as mandated in 1978 by the NFMA has become a significant part of the U.S. Forest Service's program of work over the last 25 years. Management decisions that are made in Forest Plans have been supported by a variety of analysis tools during that time. The most notable and widely used of the tools was FORPLAN that later evolved into Spectrum. A large number of Forest Plans are now being revised to comply with the NFMA's fifteen year review requirement. From lessons learned during the first round of Forest Plans, planners and analysts identified a need to simulate changes in vegetation for landscapes in response to both natural disturbances and management activities. Most Forests now have reliable Geographic Information System (GIS) data available and there is a need to incorporate more spatial information into Forest Planning analysis. Spatial information helps to address many issues identified at the Forest Planning level including the effects of wildfire, insect and disease outbreaks, and vegetation management activities on wildlife habitat, vegetation composition, fire hazard potential, scenery and landscape patterns.

Spectrum is an excellent linear optimization analysis tool but has a limited capability to provide the additional type of spatial landscape information needed today. Due to this fact, several new models have emerged to give Forest planners and analysts the ability to estimate future responses of vegetation to disturbances across a landscape while considering spatial information. This evaluation looks at three of these models. While other similar types of models do exist, these three are the models most often being used by Forests involved in Planning analysis.

- **VDDT/TELSA** – *Vegetation Dynamic Development Tool / Tool for Exploratory Landscape Scenario Analysis*
- **SIMPPLLE** – *Simulating Patterns and Processes at Landscape Scales*
- **RMLANDS** – *Rocky Mountain Landscape Simulator*

This report hopes to serve two purposes:

- To provide useful information about the capabilities of these models to Forest planners and analysts who are not acquainted with these models but are considering using them in the future

- To provide useful information to the WO Director of Ecosystem Management Coordination to be used in determining the need for a national policy and/or guidelines for the use of these types of models and the need for national level technical support for one or more of these models

3 Objectives of the Peer Review

The review was undertaken at the request of Fred Norbury, Director of Ecosystem Management Coordination (EMC) in the Washington Office (WO). Several Regional Planning Directors had requested clarification relative to the use of these models for Forest Planning analysis and that some level of technical support be provided by EMC through either the IMI or the NRIS Tools group.

The review was designed to provide an objective summary of what the models do, how they can be used and what benefits can be expected from their use. The review also addressed how the models work, their strengths and weaknesses, portability, software and hardware requirements, and how they are being applied in Forest Planning to analyze issues and estimate environmental impacts. More specifically, the review objectives were to evaluate the ability of each model to:

- Predict known vegetation successional pathways
- Provide useful information necessary to make a reasoned choice among alternative vegetation pathways
- Determine what management activities are needed to alter future vegetation pathways
- Incorporate the most current scientific information and methodologies
- Serve as a substitute for linear optimization models such as Spectrum in developing a schedule of vegetation treatments necessary to achieve desired future conditions
- Provide a means for conducting sensitivity analysis of model parameters and data to account for uncertainty.

4 Review Process and Participants

The evaluation was organized and sponsored by the US Forest Service's Inventory and Monitoring Institute (IMI). The review panel consisted of three members that represented different areas of expertise relative to the review objectives. The panel members were:

Dr. Joe Roise - Professor, Department of Forestry, North Carolina State University with expertise in Forestry, management science, and Operations Research

Dr. Joe Berry - Principal Consultant, Berry and Associates /Spatial Information Systems with expertise in spatial modeling, software development and practical application of GIS technology in natural resources

Dr. Dave Roberts - Associate Professor; Forest, Range and Wildlife Sciences, Utah State University with expertise in ecosystem and landscape modeling

The review was conducted at the Natural Resources Research Center in Fort Collins, Colorado from January 7-9, 2003. The models were presented to the review panel during 4 hour sessions conducted by the respective model developers for each model: Jim Merzenich, Analyst, Region 6, USFS for VDDT/TELSA; Jim Chew, Forester, Rocky Mountain Research Station, USFS for SIMPPLLE and Kevin McGarigal, Professor, University of Massachusetts at Amherst for RMLANDS. IMI Director Tom Hoekstra, Matt Turner, Bob Lee and Bruce Meneghin represented IMI. Advocates of the models from Regions 1, 2, and 4 also attended the presentations.

Following the presentations, the review panel met individually with each of the model developers for further questioning and discussions. The reviewers then met by themselves for a day to discuss and evaluate the models and develop a draft report of their findings. IMI staff reviewed the draft report on January 9th before the panel disbanded. The panel presented their final report to the IMI on January 27, 2003. A synopsis of the review findings is included in this report. The full report is available on request from the IMI or through the IMI website at:

http://www.fs.fed.us/institute/news_info/evaluation_LDSM_attach_a.pdf

5 Review Findings

5.1 Definition of Landscape Dynamics Simulation Models

Initially, the review panel was asked to categorize these three models using a more appropriate term than “vegetation simulation models”. The panel proposed the term “landscape dynamics simulation models” (or LDSM’s) as a more descriptive term for this category of models. LDSM’s are a recent approach to understanding the distribution of vegetation in space and/or time for large expanses of heterogeneous landscapes. The models attempt to merge two approaches to understanding resource distribution in time and space: simulation models and GIS. The models have the combined capability to portray changes in vegetation characteristics over time while tracking the spatial distribution of those changes.

5.2 Characteristics of LDSM’s

The review identified several characteristics of LDSM’s to serve as points of comparison and evaluation. These characteristics are:

- State space
- Memory
- Modeling approach to landscape dynamics
- Modeling approach to spatial characteristics and relationships

State Space - In a simulation model, the attributes or characteristics of a given location at a specific point in time is referred to as its "state." The "state space" is defined as the set of all possible states, and determines the set of possible behaviors of the model. For every location on the landscape at every point in time a model must maintain a representation of the vegetation structure and composition. This representation can vary from very simplistic to quite detailed, and is central to the character of a particular model.

The state space determines how detailed the information about a specific location is, and how fine of a distinction we can make between two locations, or a single location at two points in time. While it might appear that a model with the capability to represent a very detailed "state space" would always be better, they require significantly more data to implement, and significantly more computer resources to run. The design of the state space is an area of critical compromise, and should reflect the data availability, the available computing resources, and the nature of the questions the model is designed to answer.

Memory - LDSM's that can incorporate the history of a specific area are said to have "memory" and are capable of much more interesting behavior than models which lack memory. This capability is actually a technique for further defining the number of "state spaces" that exist in the model. For example, knowing that bark beetles had attacked a specific area, a simulated fire might consider the additional fuels from snags and down woody material caused by the infestation in calculating fire severity.

Some LDSM's can also take into account the characteristics of adjacent locations in determining the impact or effect of a disturbance. This capability can provide a more accurate simulation of effects than a model that cannot. For example, knowing that an adjacent location has a seed source for a particular species might influence the amount of time needed to regenerate an area after a disturbance.

Modeling approach to landscape dynamics - The three models reviewed reflect a range of different modeling approaches to landscape dynamics. The approaches range from very coarse to detailed representations of landscape processes. Some models use a very complex probabilistic approach as compared to a simplified one.

Models that are stochastic rather than deterministic in nature allow managers and the interested public to develop some intuition or understanding about the uncertainty of the future, and to incorporate appropriate levels of uncertainty into Forest Plans. The models provide valuable spatial and aggregated information for use in a variety of natural resources management planning. They also have the ability to simulate several scenarios and then perform sensitivity analysis to assess a range of potential outcomes over time.

Modeling approach to spatial characteristics and relationships - The three models in this review exhibit different approaches to spatially defining and tracking simulation units and for incorporating spatial relationships into transition processes.

5.3 Evaluation of the Models

5.3.1 VDDT and TELSA

VDDT has a very general state space, where individual users are free to determine the appropriate number of states to model and the definition of those states. Generally, stand development or succession is a single non-branched path in the absence of disturbance. Stand development is deterministic, without a stochastic element. VDDT comes with a large number of "disturbances" pre-defined, including: defoliators, bark beetles, dwarf mistletoe, other pathogens, wildfire of varying intensities and management activities such as timber harvesting and prescribed burning. Users can alter the provided processes or create new ones. Disturbances and management actions are created by assigning a probability of occurrence of that event for a specific state and the state an area will change to if the event occurs.

In VDDT, none of the processes are spatial, i.e. the probabilities of transition are not affected by the characteristics of other locations. VDDT and TELSA do not have direct "memory" capabilities but states can be defined based on past events. The addition of TELSA as a companion tool to VDDT provides the user a link to spatial analysis of model solutions. TELSA uses VDDT model data plus spatial map data as input and uses GIS-based tools to enable spatial analysis of landscape characteristics. TELSA was designed to operate on large landscapes containing thousands of polygons. Since TELSA models are built using the same input data as VDDT, the simulation processes are also the same except that TELSA is able to account for such characteristics as the size and spatial arrangement of management units, the distribution of patches created by management or natural disturbance, and the size of existing and created openings.

VDDT is particularly good as a learning/training tool and enables people to think about and make decisions on landscape processes. It is a good tool for sensitivity analysis of assumptions about landscape dynamics. The modeling process is a good forum to obtain agreement or consensus on landscape dynamics. The model is relatively well documented. VDDT models have been developed for most major forested and non-forested vegetative types throughout the western United States and Canada. Models have also been developed for hardwood, jack pine, and southern pine ecoregions of the east. The Nature

Conservancy, in conjunction with their Fire Learning Network, has helped to develop many of these models. The major weakness of VDDT may be that it only provides a modeling framework and requires an interdisciplinary team effort to develop. Users must develop all documentation about their specific model.

TELSA is a spatially disaggregated model representing simulation units as irregular polygons. The transition results from normal succession or disturbance impacts on predefined vegetation parcels. The mosaic of vegetation polygons act like jigsaw puzzle pieces defining the landscape at each time step.

TELSA uses a tessellation procedure to subdivide the initial polygons into a subset of smaller polygons that can be assigned to different states. For example, following a wildfire disturbance, only a portion of an initial vegetation parcel's tessellated polygons might be assigned a burned state while the rest follow a normal successional pathway.

5.3.2 SIMPPLLE

SIMPPLLE defines its states as a combination of habitat type, dominant species, size-class/structure; and density. SIMPPLLE can utilize ecological stratifications on landscapes. For specific geographic areas, SIMPPLLE maintains lists of habitat types grouped into somewhat broader classes. SIMPPLLE uses a specific vegetation structural classification that includes both Forested and non-Forested types. In the models built for the Northern Region, SIMPPLLE recognizes four density classes, based on canopy closure, and has the capability to distinguish stands of different ages within a structural stage. The vegetation attributes used to describe species, size-class/structure and density can all be specific to geographic areas.

SIMPPLLE is a spatially disaggregated model representing simulation units as irregular polygons very similar to VDDT. The position, size and shape of the simulation units in SIMPPLLE are established by the initial land cover conditions and are constant throughout a run.

SIMPPLLE includes a variety of possible disturbances, including wildfire of variable intensities, bark beetles, blister rust, defoliators and root disease. SIMPPLLE employs a fairly sophisticated fire spread algorithm, which includes topographic effects, wind, and the history of individual parcels. The model includes a number of management treatments that can be scheduled in sequence for specific management regimes. Reflecting its history of development for project as well as regional analyses, SIMPPLLE allows treatments to be assigned to specific parcels at specific times, or schedules the treatments based on future attributes, disturbance process occurrence or targets.

SIMPPLLE can represent a detailed state space, and employs numerous processes that are both spatial and history-based. Many of the specifications within the model are “hard-wired” and calibrating the model for new areas requires the assistance of the model developers.

SIMPPLLE has been effectively used in Forest wide and project level planning efforts to help analyze the results of management decisions and assisting decision makers at the programmatic level about where on the landscape treatments and activities should have high priority. The model has the potential to test the sustainability of a variety of Forest outputs that were estimated using optimization models like Spectrum or MAGIS.

SIMPPLLE can provide maps of future landscapes, probability (or risk) maps of landscapes, and table and graphic summaries displaying results. This information is used to communicate with the public the dynamic nature of a Forested landscape and the range of possible results caused by both natural processes and human activities. SIMPPLLE models have been or are being developed for a wide range of landscapes from Florida to Alaska.

SIMPPLLE is particularly good at capturing different vegetation patterns and then projecting them over time. It can clearly display the interaction between different processes and the effect of management activities and Plan alternatives over time. Currently, SIMPPLLE is not good at predicting extreme fire behavior.

5.3.3 RMLANDS

RMLANDS is a spatially explicit LDSM designed to model natural disturbances, human activities and vegetation succession processes on any spatial or temporal scale. The purpose of the program is to facilitate quantitative analysis of landscape patterns. RMLANDS is still in a developmental stage and characteristics of the current model vary from the original prototype.

RMLANDS employs a list of land types or environments. Current versions employ moderately broad land types using the Oliver and Larsen classification system (1996). RMLANDS uses a fairly simple state space with a very high spatial resolution. Simulations are driven by sophisticated placement and spread algorithms. Stand dynamics in this state space are somewhat stochastic, where an individual parcel stays in a given class for a minimum period of time, and then has a probability of moving to the next successional class. The result is that individual parcels change state at a variable rate. To minimize small-scale heterogeneity, adjacent parcels are aggregated into “patches” which change state at the same time. The model does have “memory” capability.

RMLANDS can simulate a variety of natural and human-caused disturbances. Natural disturbances can include wildfire and insect/pathogen infestations. The disturbance algorithm in the model includes 4 key components: climate, initiation, spread and mortality. Each natural disturbance is modeled with a degree of uncertainty associated with the disturbance initiation, spread and ecological effects. Management actions and treatment schedules are handled stochastically using “management regimes” defined by the user. Management regimes consist of 6 key components: spatial constraints and priorities, treatment types, treatment allocation, treatment intensity, watershed constraints and treatment unit dispersion factors. Treatment units remain under management for one full rotation after which they are returned to a pool of unmanaged lands. Both natural disturbances and management regimes are initiated at the cell level and then follow an appropriate “spread” algorithm.

Users can specify acres of a land type to receive treatments within the model. The model will assign the appropriate area to receive the treatment based on a probability function. Then adjacent cells will be accumulated until the acre objective is achieved. If the land type scheduled for treatment is no longer available because of a fire event, the treatment is not applied. The fire spread algorithm in RMLANDS is currently the most sophisticated and is a function of local vegetation structure, wind, and topography.

RMLANDS is a good tool for educating people about the dynamic nature of a landscape and the scale dependent nature of landscape dynamics. It has the ability to analyze a landscape statistically using FRAGSTATS (McGarigal and Marks, 1995) and visually look at landscape patterns over time. It can also be linked to wildlife habitat models and can be used to view possible future habitat patterns over time.

The current models for the San Juan and Grand Mesa/Uncompahgre/Gunnison National Forests are prototypes. The models were developed as a collaborative effort with input from both managers on the ground and scientists. The Forest’s analyst can set up and run their own simulations but results are interpreted by a landscape ecologist due to the complexity of the model. The analyst can make changes to several elements within the model such as stand condition transition probabilities, harvest dispersion factors, management actions and several other model elements. This capability allows the analyst to include the latest scientific knowledge or perform sensitivity analysis on different coefficients.

The high spatial resolution, which makes the model such a powerful landscape simulation tool, has the disadvantage of making the model computationally intensive. This means that the model requires a more powerful computing environment than either VDDT or SIMPPLLE.

The spatial definition of RMLANDS simulation units involves an entirely different approach than the other two models. It identifies the size, shape and area of initial vegetation parcels as a loose collection of grid cells providing a high level of spatial flexibility. The individual cells comprising an initial vegetation parcel are treated as a cohort and transition as a group through normal succession. Disturbances can affect individual cells, such as the “leading edge” of a wildfire. The result is a modeling structure that closely mimics the complex spatial character of natural landscapes. The spatially explicit structure of RMLANDS enables the model to better represent spatially dependent processes. The TELSA and SIMPPLLE models typically use a more coarse set of spatial characteristics with less detailed terrain and condition information.

6 General Conclusions of the Review Panel

The review panel could not reach any consensus on which of the three models was preferable. Each of the three review panel members favored a different model. VDDT was favored because of the inherent flexibility in landscape states and processes, the direct portability to other landscapes, the ability to serve as an educational tool when working with the public and good documentation. SIMPPLLE was favored because it contained the most biological detail on the systems it was designed to simulate and it has good documentation including a user manual. RMLANDS was favored because it has the highest spatial resolution, has direct linkages to FRAGSTATS and wildlife habitat models, and can project a large amount of spatial information. The review team was also aware of other existing LDSM’s and felt that the usefulness of these other models should also be examined.

The review panel also identified the major drawbacks of each model. VDDT is less scientifically and analytically rigorous in depicting landscape relationships than either SIMPPLLE or RMLANDS and the model cannot incorporate spatial information into the analysis unless it is used in conjunction with TELSA. SIMPPLLE requires that the developer write the initializing code on landscape relationships when a model is being built for a new area instead of having the capability for new users to enter that information through a user-friendly Graphical User Interface (GUI). RMLANDS has the same problem except that it requires more initial developer support than SIMPPLLE. RMLANDS is also computationally intensive and many disturbance and management activity relationships have yet to be programmed into the model.

While the models reviewed here have the same general objectives, the specific choices of areas to emphasize and the compromises made in implementation distinguish these models from one another. Since it is not possible to adequately model every aspect of landscape dynamics, each model developer chose certain characteristics in order to achieve specific objectives. VDDT emphasizes flexibility and open structure; SIMPPLLE has a relatively sophisticated state space and ecological resolution while RMLANDS has very high spatial resolution and elaborate spatial processes.

All three of the models provide valuable information about landscape vegetation dynamics including the effects of normal succession and the effects from both natural and management induced disturbances. In order to ensure consistent interpretation of model results, models should include a “results comparison/analysis module” testing *(author’s note- SIMPPLLE does have this capability using EXCEL spreadsheets)*. At each time step, results should be comparable to previous ones to determine the extent of changes in both graphic and statistical forms. Managers and policy makers need summary charts, indices and maps summing up the voluminous model output for a clear and consistent understanding of the landscape dynamics within and among model runs. The data provided by the comparison/analysis module should reflect information needed in addressing a finite set of specific management questions.

The number of simulation units capable of being modeled is different among the three models. VDDT/TELSA is the most limited. SIMPPLLE can handle any number of units but in the size of the initial vegetation polygons is characteristically larger than tessellated polygons used by VDDT/TELSA or the grid cells used by RMLANDS. RMLANDS appears to provide the greatest spatial precision and flexibility in simulating environmental effects although models built using SIMPPLLE could probably achieve the same level of detail if desired.

RMLANDS and SIMPPLLE make coarse representations of disturbance processes like fire. While they do not make detailed predictions of fire spread, they do support a probabilistic initiation and propagation of disturbance events through the landscape. These characteristics are closely linked to the “memory” capability. VDDT takes a much more simplistic approach and represents a disturbance in terms of the probability of occurrence on a defined state.

According to Barrett, (2001), “A model that predicts future vegetation for a particular landscape is a model. A program that has been designed so that it can be easily modified to predict future vegetation for a number of different landscapes is a modeling system.” Currently, VDDT/TELSA is closer to meeting the definition of a modeling system than the other two models. SIMPPLLE is a modeling system with easy application to Northern Rocky Mountain ecosystems but is only adaptable to other Regions and Forests with support from its developers. RMLANDS is potentially a modeling system but is currently in an early stage of development.

In general, these are strategic models, rather than tactical, and operate at a fairly high level of abstraction. Most land management issues are related to effects on vegetation structure and composition. All of the models simulate the change in vegetation structure and composition over time, and are thus suitable for input into a very broad range of Planning questions. LDSM’s can provide the basic information needed for addressing many of these issues.

7 Recommendations from the Review Panel

The recommendations from the review panel are summarized below:

- Some research needs to be done to incorporate or strengthen the objective(s) used in LDSM's. What questions are we trying to answer? The specific answer would change from region to region, however each landscape model could (or should) have a unique set of objectives.

- A goal of future development should be to create a modeling system designed to be easily modified to predict future vegetation for a number of different landscapes. The graphical user interface for models should allow the users to develop, enhance and extend states, processes, probabilities and model coefficients in a flexible easy to learn format. The envisioned modeling system would allow users to create models of any new landscape without assistance from the developer other than training.

- As landscape models are further developed, the number of spatial and memory-based processes should be expected to increase. The increase in complexity associated with this development is more than compensated for by the increase in realism achieved in the simulations.

- The USFS should provide the developers guidance about standardizing the format of model data input/output. The formats should provide for direct linkages to other programs such as Spectrum, Forest Vegetation Simulator (FVS), Natural Resource Information Systems (NRIS) and other software packages used in Forest Planning. Users should have the capability to develop data sets on their own.

- Continued development, support and maintenance agreements and procedures need to be established and funded. All three of the models were developed under a patchwork of project funding and variety of operational budgets and staffing. The USFS needs to assess the operational needs of LDSM's and identify specific Planning and management questions they address. The USFS needs to review options and procedures for internal and/or external ownership and maintenance of the software.

8 Objectives of the Review – Revisited

The objectives established for this review were re-evaluated against the results of the review to see how well the objectives were met.

Evaluate the ability of each model to predict known vegetation successional pathways

The review was able to make the determination that each model was able to meet this criteria albeit to varying degrees. It was also dependent upon the knowledge level of the individuals responsible for providing data and information used to set up the pathways being modeled.

Evaluate the ability of each model to provide useful information necessary to make a reasoned choice among alternative vegetation pathways

The review identified the types of information that can be provided by each of the models. The objective should have been stated to say what it implies; that the choice is among alternative management activities or prescriptions. the reviewers concluded that all three models could provide probability information on the results of applying specific management prescriptions as well as taking "no action". For larger landscapes, the models can be made to provide useful information necessary to make a reasoned choice among management alternatives. The only significant difference among the models is in RMLANDS where the choice of management activities is limited *(author's note- the model now has a wider variety of treatments).*

Evaluate the ability of each model to determine what management activities are needed to alter future vegetation pathways

The panel concluded that all three models could adequately provide this type of information. They also commented that the reverse was also true: that the models could be used to estimate the impacts of vegetation pathway changes on management activities.

Determine if each model Incorporates the most current scientific information and methodologies

This is a difficult question to answer and in their evaluation the panel addressed each model individually. VDDT/TELSA, being the closest to an actual modeling system, allows the users to incorporate whatever they want into the model. There is nothing in the model that inherently guarantees the data being used is the most current scientific information available. Considerable development is still needed in the spatial component (TELSA) in order to become current with the latest technological methodologies. The use of VDDT/TELSA to help conceptualize landscape dynamics and work with the public to test changes in assumptions about ecological processes is probably the most valuable benefit to using the model.

In comparison, the panel felt that the other two models, SIMPPLLE and RMLANDS are more “black box” type models. Even though these models probably contain the most current scientific information and methodologies, the results may be less acceptable by the public due to their perceived “black box” nature. SIMPPLLE incorporates the most current scientific information and methodologies as defined by developer Chew to be most appropriate after conducting numerous workshops with resource specialists in the early stages of model development. SIMPPLLE’s structure contained the most information about how a landscape evolves. RMLANDS incorporates science as summarized by McGarigal and others. Linking RMLANDS outputs to FRAGSTATS does provide additional useful measures. RMLANDS incorporates the most detailed science and methodologies.

Determine if any of the models could serve as a substitute for linear optimization models such as Spectrum in developing a schedule of vegetation treatments necessary to achieve desired future conditions

None of these models can serve as a substitute for linear optimization models such as Spectrum. The reason is due to their inability to consider more than one set of possible management regimes at a time. Models such as Spectrum analyze the tradeoffs between thousands of different management choices and then select the one that “optimizes the objective function”. The immediate problem with linear optimization models is that they are largely deterministic rather than stochastic. This fact makes models such as Spectrum less capable at incorporating probabilities, uncertainty and risk into their “solutions” as compared to the LDSM’s reviewed here.

The combination of SIMPPLLE and MAGIS comes close to serving as a substitute for a strategic linear programming model. MAGIS is a mixed integer programming model designed for tactical planning of vegetation treatments and transportation system maintenance. In some test projects, fire risk indices were developed using SIMPPLLE and treatments were scheduled with MAGIS. Iterative analysis between the two models was very helpful in gaining insights by modeling representative landscapes for a Forest.

Evaluate the capability of each model to provide a means for conducting sensitivity analysis of model parameters and data to account for uncertainty.

The panel concluded that all of the models are good tools for doing sensitivity analysis. All three can do multiple batch runs testing the effects on model parameters.

9 Practical Applications of LDSM's

VDDT has been used to evaluate alternative fuels treatment scenarios, to assess historical fire regimes, and the effects of epidemic insect and disease outbreaks over broad landscapes. SIMPPLLE has been used to evaluate large landscapes and for project level planning. The model has been used to estimate the effects of mountain pine beetle activity, identify potential future old growth conditions, and evaluate and schedule alternative fuels treatments. RMLANDS is in a relatively early stage of development and has yet to establish a legacy of successful applications.

For roadless area issues, SIMPPLLE and RMLANDS would be preferable due to their ability to incorporate more spatial information unique to specific roadless areas. The models could be used to simulate what is likely to happen to the areas as they are left to only natural succession and disturbances or scheduled for a series of different vegetation management prescriptions.

This same approach could be applied to the analysis of wildlife habitat. Any of the models could be used to estimate future effects on wildlife habitat, however, when the spatial location of that habitat is important, such as critical habitat for threatened, endangered or sensitive species, then SIMPPLLE or RMLANDS will provide better analytical results.

If time is a critical factor to a Planning team, then a VDDT model would be the easiest to construct. SIMPPLLE and RMLANDS require more data and therefore, more time to develop a new model. VDDT also has more extensive documentation.

RMLANDS has not been as extensively used as VDDT and SIMPPLLE and is in process of being tested as a useful Forest Planning analysis tool. Given the models capabilities for handling complex and detailed spatial information, the RMLANDS model may be better suited for project level planning or watershed level assessments.

Most users of these models would agree that the models have utility beyond the analytical questions answered by them. The process of building a VDDT model has helped several ID teams develop a common view amongst themselves and the public of the natural processes they are trying to model. Continuous refinement of the SIMPPLLE model with the involvement of specialists in the Northern Region has led to standard Forest state definitions and agreements about process behavior in that Region. RMLANDS has also engaged many specialists and is becoming a knowledge store of Regional expertise.

VDDT would best be used in a collaborative setting where quick agreement on landscape relationships needs to be achieved and rapid display of alternative solutions is desirable. SIMPPLLE would best be used in situations where it is desirable to be more rigorous in the depictions of landscape relationships in a spatial setting and can be linked to other vegetation based models that use the same set of attributes such as the GAP models used by Montana and Idaho. RMLANDS would best be used where time is not a constraint and where a detailed set of landscape relationships and a link to wildlife habitat models is desired. Although it has not been done to date, these models could be used in a complementary fashion. The public and the ID Team could use VDDT initially to facilitate understanding of landscape relationships. SIMPPLLE or RMLANDS could be used to analyze those relationships in a spatial context. VDDT could be used again to graphically display alternative future pathways resulting from natural or human-caused disturbances.

10 Policy Implications

Clearly, LDSM's can be used as valuable analysis tools in the Forest Planning process. As noted by the review panel, however, any of these models are vulnerable to factors that could render them unavailable or ineffectual. The consequences of maintaining the current situation needs to be considered when deliberating over the question of whether to institutionalize any of these models as was done with FORPLAN/Spectrum during the first round of Forest Planning. Experience has shown us that significant continuous investment is required to realize benefits from nationally supported models. Software development and maintenance is never-ending and widespread availability is no guarantee of effective application of such models.

To assess an LDSM as a candidate for national level support, a standard software investment analysis should be conducted. Each model would be assessed based on its abilities to meet well defined business needs. A life cycle cost analysis should be completed. The current situation does not allow for such a comprehensive analysis. Business requirements for Forest Planning analysis are being defined as part of the Forest Plan Vision process and are not finalized. Forests involved in Plan revision can base their analysis on the Planning regulations issued in either 1982 or 2000. A completely new set of proposed NFMA regulations is currently out for public review and comment. A Forest Plan Vision team is currently revising the requirements for a Forest Plan document based on the proposed regulations.

The development costs of these models are fairly well known and reasonable estimates of future development scenarios could be developed. Such an analysis is beyond the scope of this report. The full development costs of these models may be higher than standard accounting procedures may reveal. Development costs should include the time required to develop the landscape relationships unique to any given National Forest and incorporate the knowledge and views of the users and the public into the models. This is a costly activity but one that is critical in order for a model to be understood and accepted. Any new model developed by a Forest will require this step regardless of whether the model is nationally supported or not. There could never be a “one model fits all” situation even if one of these models were upgraded to a “modeling system” status.

The need for this type of analysis tool obviously exists or the models reviewed here never would have been developed in the first place. If the use of these types of models helps to improve our Forest Plan decisions then their use should certainly be encouraged. The current situation for development and maintenance of these models is very inefficient. A better environment would involve some level of national support that would provide a long term commitment to the use of LDSM’s. Another advantage of this approach would be the establishment of a central clearinghouse of knowledge concerning the use of the models which could create an environment of continuous improvement for Forest Planning analysis tools in general.