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INTEGRATING FIRE MANAGEMENT & LAND USE PLANNING

- A good idea, but can we work it?

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INTRODUCTION

In 1974, the West Australian Government endorsed the concept of multiple use management of the forest estate, as proposed by the Forests Department. Simply, this means the use of land for several different purposes (GWP - 87). Priorities for use are determined for each area, based on its attributes and social demands placed on the area. As outlined in General Working Plan No. 87; "the ranking of priority uses recognizes that compatible secondary uses and tertiary uses are vital to the total use allocation system". Major forest values recognized in the Working Plan are; water, wood, flora, fauna, landscape, recreation, scientific study, education and minor products such as honey, sandalwood, wildflowers etc.

What about fire? Fire protection is a necessary first step to managing the forest estate. The protection of people, property and forest values is a pre-requisite for integrating fire management into land use planning. With increasing demand for multiple and competing forest uses, fire management must include concerns for economic and ecological considerations. viz., within the fire protection framework must lie fire management strategies which enhance forest values to society. It may well be that within the fire protection plan currently practised, land use objectives are optimally achieved. However, recent research findings by Shea & Christensen suggest that this may not always be so. From a planning viewpoint we must be able to predict the consequences of various fire management activities. Integrating fire management into land use planning requires a knowledge of the ecological effects of fire regimes and the ability to implement desirable regimes - i.e. a sound practical knowledge of fire behaviour.

In an attempt to integrate fire and land use planning, the U.S.D.A. Forest Service are developing a Research, Development and Application Programme. The programme mission (as outlined by Lotan) was to improve the land manager's capability to integrate fire management considerations into land use planning and management activities. The operational goals are as follows:

(i) Define the role of fire in forest ecosystems and enhance the land manager's ability to prescribe and predict fire behaviour.

(ii) Develop procedures and techniques to integrate fire management into the land use planning process. Develop management and inventory techniques to meet fire management needs of the land manager.

(iii) Apply operational fire management plans on specific planning units or projects and evaluate fire management alternatives for selected land uses. Demonstrate these and provide the <u>means</u> for transferring the methodology to user groups.

These goals relate to the research knowledge required, the development aspects and the application of the programme. For West Australian forest types there is a considerable amount of information on fire effects and fire behaviour. Current and future research will expand these areas.

GOALS OF FIRE MANAGEMENT

The following is taken from a discussion paper by Lotan (1979).

"We will not have adequate fire management until all activities of a fire organization - including prevention, control and beneficial use of fire - are directed by land management objectives. Because it cuts across so many resource management boundaries and affects both short term and

long term resource outputs, the only effective way to deal with fire is on a multi-resource, multi-objective basis. Further, because fire does not respect property boundaries, planning must consider the objectives of all land owners involved."

It is essential to be able to predict the ecological and social consequences of various fire management activities. Obviously, such predictions can only be made with state of the art information. It is also essential that, having determined the most favourable fire management activity tailored to land use objectives, the activity can be implemented without compromising protection to people, property and other secondary forest uses (although the latter is a decision for land use planners). Planning requires stratification of the forest environment in space and time. For each stratification, there is a need for a measure of the range and distribution of consequent results (again, based on state of the art information).

A formal programme is needed to further define the role of fire on forest values such as water, recreation, etc. State-of-the-art fire effects and behaviour models need to be accessible to the land use planning process and to land managers in a readily useable form. There is also a need to evaluating the success of meeting the fire management needs of the land manager.

The following is a proposed framework for integrating fire. This framwork is based on FIRELAMP, which is a multi-resource model that simulates the effects that natural and prescribed fires have on the future production of natural resources such as timber, water, flora, fauna, etc. The FIRELAMP computer simulation model is being developed by scientists at the Northern Forest Fire Laboratory in Missoula, U.S.A.

FIRELAMP

FIRELAMP is a conceptual framework for integrating fire and forest values.

OBJECTIVES OF SUCH A SYSTEM

(i) to simulate the ecological effects of fire on the forest system

(ii) directly utilize fire behaviour model outputs

(iii) address forest fire management and planning questions

(iv) provide an interface for simulating fire management practices to maximise forest benefits.

SCALE

(i) forest block size land units - i.e. 4-10,000 ha

(ii) shortest time scale - 1 year

(iii) longest time scale - 200 years

(iv) some subsystems such as weather and fire behaviour models would operate on a daily basis

(v) water on a monthly basis

(vi) fauna - 1 year

(vii) flora - 1 year

(viii) timber - 1 year.

Obviously, we do not have all the answers to model the effects of fire on the above forest values over the given time scales. However, I believe adequate information exists to construct a model. Modelling is a tool that can be used to provide answers that are difficult to determine experimentally. The reliability of these answers is a function of the base data, which can be improved and increased with time. The model can also be used to plan research effort as information needs are readily identifiable.

Attempting to develop a model will simulate over a considerable time period, the likely consquences of fire management activity on various forest values could simply "generate a bowel of spaghetti-bolagnaise, where the user then has to fish out the mushrooms". The level of complexity, resolution and accuracy of the FIRELAMP concept is largely set by the data base, but the degree of synthetic simulation required is best decided by the user of the system.

I will introduce the FIRELAMP concept under a series of sub-systems which I see as being important to fire managers in Western Australia. Much of the methodology outlined is from recent communications with fellow workers at the Missoula Lab in U.S.A.

WEATHER SUB-SYSTEM

In Western Australia, we have in operation a weather forecast and dissemination system. This is the driving system of the fire behaviour model. Daily values of rainfall, maximum temperature, minimum relative humidity and wind speed and direction are necessary to drive the fire behaviour model. The Americans recognize two basic approaches to producing a time series for these variables (over the time scales mentioned above); (i) an observed time series from a weather station or (ii) synthetic values generated using a stochastic weather simulator. The Americans opted for the second approach which I believe to be useful for long term simulation of likely fire weather conditions for use in prescribed fire planning and predicting the likelihood of wildfire events.

The first stage of the weather simulator used by the Amercians is a programme to produce daily and monthly weather values for the time period simulated. These values are stored on file. The second stage of the weather generator is used as the model is run. Weather values are called up from storage by portions of FIRELAMP which need weather information. This can also be overridden by actual inputs. A weather simulator can be constructed by first stratifying the year into seasons. Then, for each season, select a driving variable which would be one which (i) correlates best with other variables and (ii) has highest auto correlation (i.e. its value on day 2 is a function of its value on day 1). The driving variable can be generated, for each season, on a probability basis from past weather records of each Division. Again, the degree of resolution should be determined by the user. The probable value of other variables can then be determined.

<u>STEPS</u>

(1) Weather variables required are;

- max. temp.
- min. R.H.
- dewpoint
- rainfall
- windspeed and direction

(2) Obtain records (25 years or ~~similar~~ more).

(3) Stratify into seasons.

(4) May have to further stratify into wet, normal, dry years.

(5) Select driving variable (as discussed) for each season.

(6) Determine correlations and auto correlations.

FIRE BEHAVIOUR SUB-SYSTEM

The objectives of this sub-system would be;

(i) simulate fire occurrence and behaviour

(ii) provide management scenarios for hypothetical fire regimes such as might be encountered under suppression or prescribed burning programmes.

The evaluative criteria for wildfire occurrence would be provided by fire history. Simulations of fire behaviour are conducted under a range of weather, fuel and topographical influences. Fire behaviour descriptors include;

(i) energy release rate
(ii) rate of spread
(iii) flame height, length
(iv) scorch and defoliation height
(v) fire intensity
(vi) fuel removal for each fuel class
(vii) fire perimeter and area

Much of this information has been modelled and together with current fire behaviour research should provide us with a very reliable fire behaviour prediction system. However, there are other inputs not considered, which will affect decision making processes - (i) probability of wildfire occurrence by forest or vegetation type (probably the former), (ii) probability of wildfire occurrence by time of year, (iii) probability of wildfire occurrence by size class.

The process used in FIRECAMP can be summarized;

1. For each Forest Block or Division, determine the relative frequency of historic wildfires by forest type.

2. Calculate a set of frequencies for each forest type (in the block or division) of wildfire occurrence for each month of the year. This will give a distribution of non-prescribed ignitions throughout the fire season characteristic of each forest type. Implicit in this are factors such as weather regime, recreational use etc. - factors which are important in the fire ignition history of the forest type. Non prescribed ignitions include man caused and lightning. Changes in the forest fire protection programme (burning, logging, dieback mapping, etc.) may cause an increase or decrease in the number and size of non prescribed fires. The user adjusts these numbers accordingly.

After determining the number of fires both prescribed and non prescribed to be ignited for the year, they must be scheduled. Initially, each non prescribed ignition is randomly assigned a forest (or vegetation) area based on historical distributions. Each ignition is then scheduled for a month of the year, based again on historical distribution, and then randomly, on a day of that month, based on the number of days in the month. At this point each non-prescribed ignition is defined by calendar date and forest type. As each day is simulated in the fire sub-system, the schedule is checked for one or more non-prescription ignitions likely to occur. If a fire is to occur, the behaviour parameters are calculated for that days weather, fuel moisture content calculations, and forest type (including fuel and topography). Similarly for prescribed fires, checks are done on each of the windows specified for prescribed burns. If all conditions are met, a prescription fire occurs.

TIMBER SUB-SYSTEM

This sub-system simulates the dynamics of the true component with emphasis on the effects of fire. This model is non-site specific but accommodates several different species. For Western Australia, it would be designed to accommodate karri, jarrah and pines. It would best be designed for rotation age for all forest types.

The specific objectives include;

1. Simulate the effects of fires generated in the fire behaviour of sub-system on tree growth, mortality, form, timber quality and regeneration.

2. Simulate the effects of fire regimes on vegetational changes (e.g. for Western Australia - the effect on hard seed species (such as *Acacia pulchella* and the effect on *B. grandis*, etc.). For Western Australia, much information is available on the effects of single fires and fire regimes on trees and understorey vegetation. This sub-system would provide dynamic information on the forest vegetation as input to other resource sub-systems (fire behaviour, fauna, flora, water and recreation).

3. Provide for yearly input of management activities including cutting, thinning, prescribed burning such that a wide range of management scenarios can be evaluated.

4. To identify areas of deficient knowledge and future research needs concerning fire effects on timber.

This sub-system incorporates the major direct effects of fire on the forest ecosystem through vegetational response to fire. Major features of the model include;

1. A low resolution growth and yield simulator for each different timber types for forest block sizes.

2. A reproduction sub-system simulating establishment of stands following fire as a function of stand, fire and climatic factors.

3. Simulation of fire mortality and stand damage based on fire parameters affecting crown and cambial damage - response can be in the form of density reduction, population size class redistribution or total loss.

4. A multiple pathway succession based on species characteristics, climatic factors and fire periodicity.

5. A management interface which allows yearly scheduling of timber operations.

Stand structure for most forest blocks is filed on the FMIS utilized by the Department. The primary requirements are for the sub-systems outlined in points 2 - 5 above. Again there is quite a lot of information already in existence on fire and stand damage but it is not in a readily useable form.

It should be stressed that this sub-system is intended to act primarily as an integrator of timber resource production and development, and fire effects. Its use is limited to situations in which fire is the primary question. For example, to determine the impact of wildfire or to determine the likely outcome in terms of the timber resource, of alternative prescribed burn strategies. It is not for use in simulating resource data. The model also requires reliable stand age/class stocking level information to allow the determination of fire effects.

FORAGE SUB-SYSTEM

This sub-system is designed to be a dynamic model demonstrating fire effects on the understorey vegetation. Specific objectives include;

1. Low resolution - so that extensive and unnecessary data collection is avoided.

2. Fire response - demonstrate varying vegetation responses to differing fire regimes by forage groups (grasses and shrubs such as rootstocks and legumes regenerated after fire).

3. Management output - provide the manager with the available animal unit month by month and year by year.

Resource interaction - utilize information from and/or pass information to other sub-systems.

While there is a problem of available data in some forested areas, areas such as the Perup F.P.A. have a wealth of available data which could be readily used in such a sub-system for the management of fauna populations. Biomass predictions of various forage groups following fire is readily obtainable for various season fires and fires of various intensities. Post burn assessment of the McCorkhill Block study will provide further productivity levels of forage groups following a variety of fire intensities. Forage cover and height changes following fire are also available for most vegetation types where these variables are important (such as P.F.P.A.). This sub-system would also simulate the effect of no fires on forage groups.

WILDLIFE SUB-SYSTEM

This is closely linked with the above forage sub-system and would be designed as a simple simulation tool to provide forest planning and resource developers with reliable information pertinent to their decision making processes. The model and measured response should cover all bird and animal populations in the area. For many species, the model could utilize the high resolution information available (woylie, tammar, various birds, etc.). However, for most forest blocks (outside fauna M.P.A.s) a lower resolution model is all that is required which need only operate on a yearly time step, converting measures of vegetative structure and composition into wildlife habitat components and evaluating the suitability of these for wildfire. The likely outcome of various fire activities on secondary values such as wildfire, can be obtained, probably with a low level of confidence. Nonetheless, as information comes to hand, the data base, hence the resolution) can be improved.

RECREATION SUB-SYSTEM

The objective of the fire effects model for recreation resource is to simulate change (amount and type) in recreation opportunities supplied due to forest fires of different periodicity and intensity.

The relationship between physical changes in the resource base (as a result of fire activity) and quantity of recreation opportunities supplied, is not well defined. The fact is, the supply of recreation opportunities cannot be determined solely by tree structure, stocking levels, vegetation biomass production etc. The supply of recreation opportunities as affected by fire activity is a function of management objectives for a particular land unit as well as the condition of the resource. For example, it is doubtful whether the car rally enthusiast would be concerned by defoliation following a fire, however, the picnicker from the city may be.

Thus, a straight forward, logical method is needed that will adequately account for the physical changes in resource based caused by fire, and relate these changes to the supply of recreation opportunities.

The Americans have used Brown's (1978) criteria in developing a recreation sub-system mdoel, these being;

1. It should have intuitive appeal to managers and give relevant and useful results.

2. It should be adaptable to the land planning and management processes.

3. It should give consistent results when replicated in the same area by different people.

4. It should provide objective criteria for evaluating the recreation potential of different types of resources.

5. It should ensure that the total range of opportunities are covered.

6. It should not be overly complex.

7. It should be based on tested social and behavioural science theories.

8. It should build on existing systems.

Recreation resource management like timber, wildlife etc., is a production process (Hendee, 1974). The basic questions to address are; how will fires of different frequencies, intensities and size affect the production of recreation goods and services.

In Western Australia, we have determined what type of recreation opportunities exist and we have good information on the behaviour pattern of recreators. Outdoor recreation is a complex and multidimensional component of natural resource management and planning. Thus, the systematic analysis of the various components that contribute to the production of recreation opportunities can aid decision makers greatly.

WATER SUB-SYSTEM

This has been developed to simulate the water resources response to fire activities that influence vegetation.

Outputs from such a model include:

- water yield
- sediment yield
- chemical concentrations (esp. T.D.S.)

This requires an understanding of (i) the hydrological cycle, which, in the jarrah forest is very complex, and (ii) an understanding of how fire activities interfere or influence this cycle by the effect of fire on vegetation.

Water is unquestionably a most valuable product of the northern jarrah forest. Much work has been directed to understanding the hydrological cycle including the effect of forest removal by cutting on water yield and quality. However, there is little information on the effects of various fire regimes on water quantity and quality. It has been demonstrated that cool prescribed burns have no effect on the water resource and there is poorly documented evidence suggesting that severe wildfires can increase water yield but decrease water quality. I am confident that fire can be integrated with forests managed for water to increase the supply of fresh water. This will be the topic of a state-of-the-art paper I am currently compiling.

CONCLUSION

Wildfire and prescribed fire can have significant impacts on the land system being managed. These impacts can be rated as good or bad. Current prescribed burning practices, to date, can be rated as having had a benign effect on forest resources in the direct sense. However without such a successful protection burning programme, we could not even contemplate using fire to enhance the forest resource base. I don't believe it is adequate to ask "what is wrong with our current use of fire?", I believe we should be asking "how can we use fire to enhance the many uses demanded of the forest and to maximise the benefits to society?". Already we have a great deal of information pertaining to the effects of fire (whether wild or planned) on various forest values but such information is not readily accessible to those decision makers who need it. A system, such as outlined, should fulfill this need.

It is my belief that as a fire management research section, we should be moving into the area of preparing systems such as outlined to ensure that fire effects, both planned and unplanned, are fully realized, are and can be put to use to the fullest to achieve Department objectives. It would also be evident that the system outlined requires input from other specialist branches and, most importantly, from the user group.

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