CRITICAL DATA REQUIREMENTS FOR THE EFFECTIVE MANAGEMENT OF FIRE ON NATURE CONSERVATION LANDS IN SOUTH WESTERN AUSTRALIA

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SUMMARY

Decisions relating to the management of fire on nature conservation lands should be based on a sound knowledge of the natural resources of the area and the processes that sustain those resources. Administrative, legal and cultural factors must also be taken into consideration. Critical data requirements correspond directly to the fire management objectives of the reserve and must address four key questions:

1 What are the past, current and likely future regimes of fire in the reserve?

2 How does the biota respond to these regimes?

3 How does fire interact with reserve neighbours and visitors?

4 What activities can be undertaken with the available resources?

In this paper we propose a set of critical data necessary for the effective management of fire on nature conservation lands in south-west Western Australia. A framework is derived that is applicable to all reserves but has the flexibility to cater for the management requirements of individual reserves. Strategies for management in the absence of critical data are also proposed.

INTRODUCTION

Policies and objectives for the management of fire have evolved rapidly in recent years in response to changed land use objectives, improved information and increased public awareness of environmental issues (McCaw and Burrows 1988, Good 1981). Fire management in conservation reserves should be based on a firm understanding of the role of fire in the ecosystem. However, the field of fire ecology is extensive and the resources available to undertake the necessary studies are limited. Additional factors including legal and administrative constraints, and local attitudes to conservation must also be considered in fire management decisions.

Specific objectives for the management of fire should be consistent with the overall management goals for a reserve. Clear statement of these goals in a formal management plan or set of interim guidelines for necessary operations should therefore precede the formulation of specific fire management objectives. Underwood (see p. 27) provides a series of guidelines to assist with the process of objective setting.

Planning for fire management on nature conservation lands must address four key questions:

1 What are the past, current and likely future regimes of fire in the reserve?

2 How does the biota respond to these regimes?

3 How does fire interact with reserve neighbours and visitors?

4 What activities can be undertaken with the available resources?

Critical data that can be considered necessary to answer the first three questions at a level of detail appropriate to a particular reserve at a given time. The fourth question addresses the extent to which critical data can be effectively used for management. This may be a significant factor if the resources available do not adequately reflect the perceived value of a reserve.

Data Requirements

Fire Regimes

The frequency, intensity and seasonality of fire together characterise a fire regime (Gill 1975). The areal extent and shape of individual fires may also be important in determining the rate of recolonisation from adjacent areas and the impact of grazing animals (Grubb and Hopkins 1986). The range of fire regimes within a reserve will be determined by two primary factors:

(a) the opportunity for fire spread, which is dependent on fuel characteristics and weather conditions; and

(b) the risk (Luke and McArthur 1978) or probability of fire ignition.

To adequately define the opportunity for fire spread, fuel, topographic and weather information should be integrated in the form of a fire behaviour model. For planning purposes fire behaviour models should provide unbiased predictions over a wide range of conditions, although a high level of precision may not be required. Fire behaviour models developed in Australia for grasslands (McArthur 1977, Condon 1979) and eucalypt forests (McArthur 1967, Sneeuwjagt and Peet 1985) predict fire behaviour according to basic weather and fuel quantity inputs. Being empirically derived, predictions of fire behaviour from these models are most reliable when fuel conditions are similar to those for which the model was developed. The fire spread model developed by Rothermel (1972) and its derivatives have potential for application in a wide range of fuels but require detailed information about fuel characteristics: considerable field calibration of such models will be required in most circumstances (Catchpole 1987).

Fuel characteristics such as structure, quantity and distribution will be strongly influenced by the nature of the vegetation and the time since previous fire; maps of vegetation type and fire history are therefore critical. Additional information useful in fire behaviour prediction can be obtained from vegetation maps including the impact of canopy height and density on wind strength, potential for crown fires and long distance spotting, and the necessity for mop-up of burning woody debris or peat following fire. Depending on the size and complexity of the data base involved this information may be readily handled by map overlays, or may require computer-based geographic information systems (Kessel and Good 1985).

Adequate fire behaviour guides are not currently available for many fuel types in Western Australia, and even with a substantial committment to ongoing research this situation will prevail for some time to come. However, local experience combined with analysis of historical weather and fire data can provide an adequate basis for examining possible fire regimes in different vegetation types. Daily records of rainfall, maximum temperature, minimum relative humidity and wind speed and direction are available for most settlements and form the basic inputs to several of the fire behaviour models widely used in Australia. Preliminary analysis of this basic information will allow definition of periods when fire spread is unlikely, fires of low to moderate intensity may occur, or when there is a high probability of fires rapidly becoming intense and uncontrollable.

Reserves that generate a high level of interest tend to pose complex issues for management and therefore require comprehensive data on which to base decisions. The increasing level of public interest in the management of fire on conservation lands makes it likely that sophisticated computer systems incorporating geographic and fire behaviour information will become necessary (Kessel and Good 1985).

The second major factor determining fire regimes is the risk, or probability of fire ignition. In the forested areas of south-west Western Australia, human activity is responsible for about 93 per cent of unplanned fires, with lightning accounting for the remaining 7 per cent (Underwood and Christensen 1981). Careful analysis of historical records of unplanned fires is important in quantifying the level of risk. Such records should describe

(a) the cause of the fire (eg lightning, arson, escapes from campfires, industrial operations or prescribed burning);

(b) geographic patterns of fire occurrence;

(c) seasonality of fire ignition; and

(d) the size of the fires.

Analysis of these factors may suggest ways in which the frequency of unplanned fires could be reduced through enforcement of regulations, public education or alteration of activities which entail a high risk of fire. It also enables the provision of an effective detection and suppression system.

Where land use patterns are changing rapidly, historical fire regimes may not necessarily provide a good indication of future fire regimes. For example escapes from high intensity agricultural clearing fires have been a major cause of summer and autumn fires in reserves in the south-west of Western Australia in the last fifty years. However, clearing fires are now infrequent in areas where agriculture is fully developed. Burrows *et al* (1987) reported that the area of Dryandra forest burnt by wildfires declined markedly after 1960, corresponding with the completion of land clearing in the district. Historical changes in fire regimes are important in determining appropriate or perceived necessary regimes in the future.

Response of the Biota to Fire

The response of the biota to fire regimes is a crucial element in making decisions about the use of fire. Although there have been many studies of the effects of a single fire, few studies have been published on the response of the biota to fire regimes. Nevertheless it is possible to make fairly accurate and reliable predictions on the basis of results from studies of single fires when they are coupled with a good knowledge of the life history strategies of the component organisms (Burrows *et al* 1987, Hopkins and Saunders 1987). The three types of information on the biota currently most requested and, when available, most readily applied by reserve managers are:

(a) the identity, location and extent of plant community types and areas rich in fauna;

(b) the identity, location and extent of the habitats and requirements of vulnerable species; and

(c) the identity, location and extent of key taxa and how fire management can ensure their continued role in community organisation.

In this section we examine critical data needs relating to communities, vulnerable species and key taxa and examine the role of monitoring in gathering such data.

Communities

The definition and delineation of plant communities and their correlation with landform/soils maps is an important step in land use planning (Havel 1981). Managers of public land need an objective, explicit basis for determining broadscale management units and for distinguishing the community types within their jurisdiction. Classification schemes must be able to be related to conveniently mapped characteristics if they are to be effective in reserve management.

Maps of landforms based on geomorphological characteristics have proven valuable in studies of land use, (McArthur and Clifton 1975), plant community patterns (Heddle *et al* 1980, Cresswell and Bridgewater 1985, Wardell-Johnson *et al* in press) and as a basis for stratifying samples for survey purposes (McKenzie 1984, Burrows *et al* 1987, Wardell-Johnson *et al* in press). An understanding of the relationships of communities to climatic and edaphic factors enables the definition of similar sites and establishes their extent and distribution within and between reserves. Site specific work can thus be extended beyond initial survey sites thereby placing detailed local studies in a broader regional context.

Scale is an important factor in assessing the usefulness of landform/soils and vegetation mapping; and in the location of areas rich in fauna. A first step for the breakdown of units should be within a broad region eg Churchward and McArthur (1978) and Churchward *et al* (1988). Such studies enable the portrayal of broad scale patterning and the assessment of the adequacy of the reserve system. However, to be valuable in reserve management important reserves within a region should be mapped at finer resolution. Landform soils mapping at 1:25 000 (Churchward personal communication) has proven valuable in management for the conservation of Tammar wallabies (*Macropus eugenii* Desmarest, 1817) in Perup Nature Reserve (Figure 1) by facilitating the prediction of the potential extent of thicket distribution within the reserve.

Areas rich in fauna should be considered at fine scale within the reserve system and have been related to nutrient distribution in NSW (Braithwaite 1983). Nutrient rich areas could be mapped from vegetation types. If the agents governing the pattern of distribution are known, further areas can be determined, suitable sites artificially created and translocation programmes carried out.

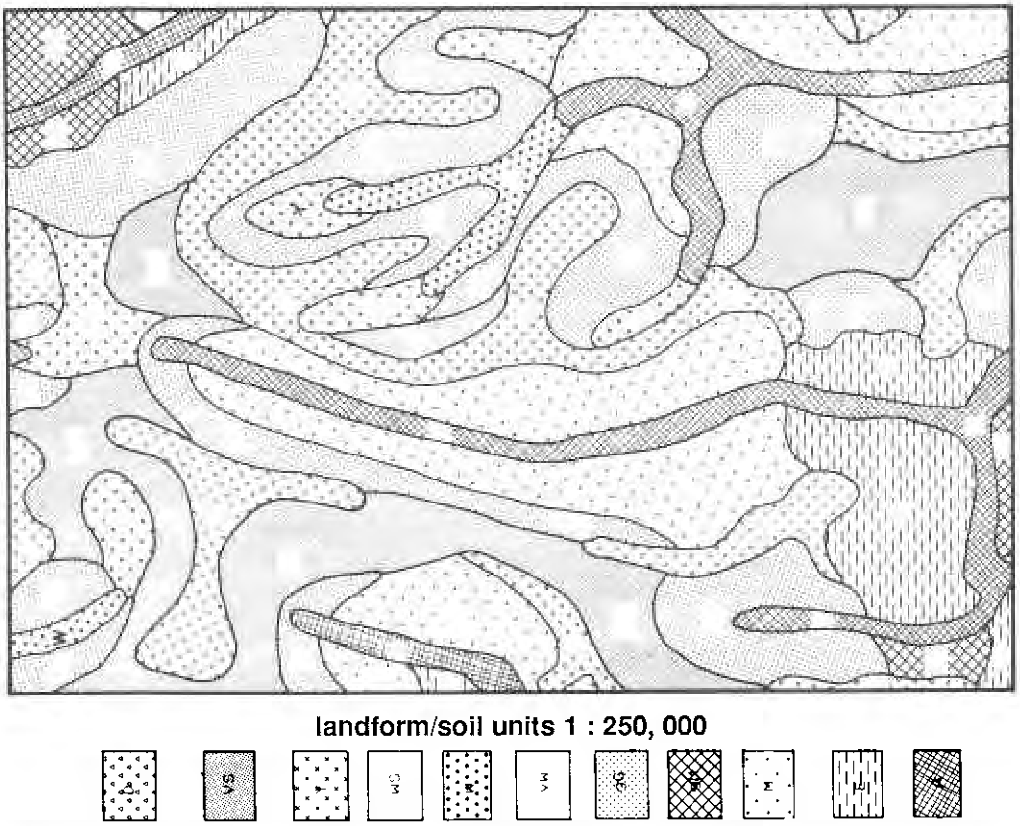
Vulnerable Species

Vulnerable plant species are defined as those species whose populations can be reduced or eliminated by inappropriate management regimes. These species may have low ecological tolerances (Austin and Belbin 1982) or regenerative characteristics (Gill 1981) that are dependent on particular disturbance regimes. Species that are susceptible to disease wherever they occur, should be considered vulnerable.

The identification and mapping of vulnerable species is necessary if we are to be successful in managing for the continued maintenance of their populations at a local level. Because of the high rate of endemism (Hopper 1979) many of the species in the south-west are likely to be vulnerable. Such species may be rare or restricted, and where vulnerable, are often at the edge of their ecological range. Rarity in itself, however, is not the major consideration in the conservation of vulnerable species. For the purposes of fire management planning the distributions of vulnerable species and their regenerative characteristics need to be determined so that operations can be designed accordingly.

Many fire sensitive obligate seed regenerators are regarded as vulnerable (Plate 1). The primary juvenile period or age to reproductive maturity is important for the conservation of these species (Gill and McMahon 1986). Many species with fleshy underground storage organs may be vulnerable to fire during their flowering period when most of the plants resources are allocated to reproductive effort (Pate and Dixon 1981). The season of flowering is a primary consideration for the conservation of such species.

Some species of fauna require special consideration if populations are to be conserved.



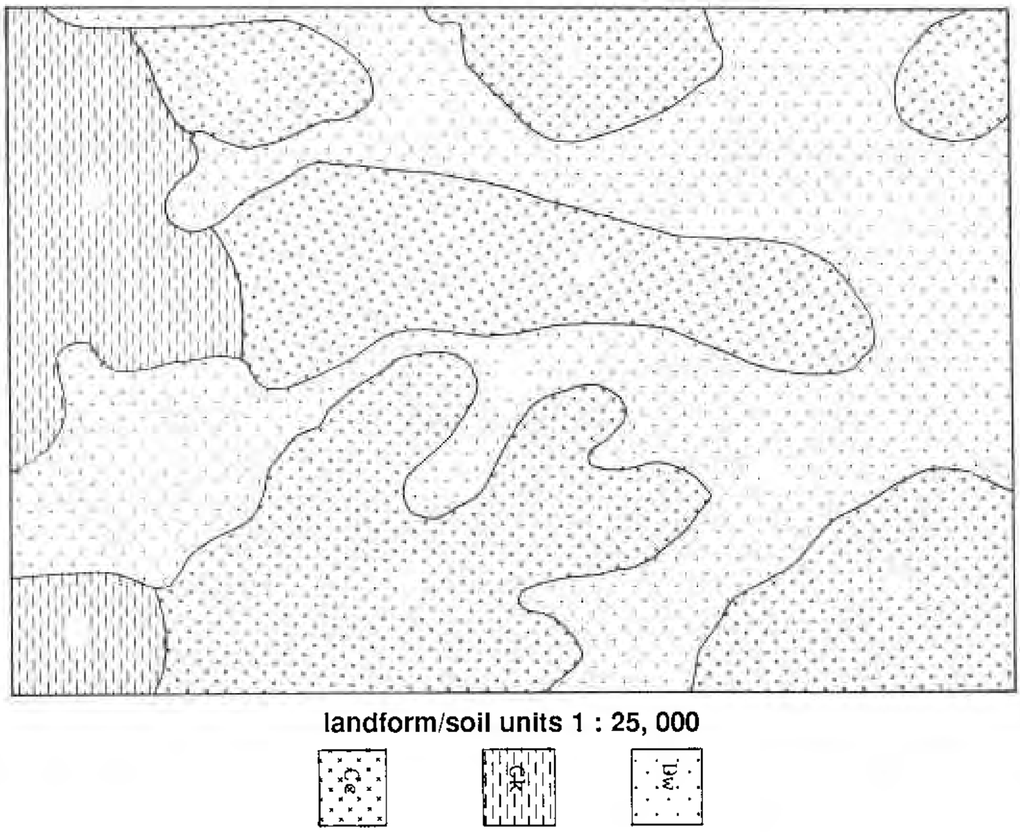


FIGURE 1

Scale in landform soils mapping: an area of the Perup Nature Reserve mapped at 1:250, 000 and 1: 25, 000. <u>Gastrolobium bilobum</u> (heartleaf) has the potential to form thickets on subunits defined at the finer scale enabling the prediction of potential thicket extent.

Plate 1 A stand of *Banksia seminuda* subspecies *remanens* (Hopper, in press) four years after fire in the Walpole-Nornalup National Park. The seedlings that have replaced the stand killed by fire require an estimated minimum of 10 years without fire before producing seed.

Vulnerable animal species are defined with respect to their habitat requirements as those species that are dependent on habitat components that can be eliminated or diminished by disturbance, or are dependent on particular successional stages triggered by disturbance.

Vulnerable species tend to have low population densities (constitutionally rare), be specialists of patchily distributed habitat or successional states, or have low dispersal ability. Species may be vulnerable at the periphery of their range and resilient near their range centre (Hengeveld and Haeck 1981, 1982; Kavanagh and Kellman 1986). Vulnerablity can be exacerbated by fragmentation of habitat, the introduction of, or failure to control, pests and diseases and/or inappropriate management regimes or activities.

Lists of species considered as vulnerable and therefore requiring specific consideration in management should be completed for each reserve. This requires an accurate knowledge of the current distribution of species. The availability of computer-based climatic data retrieval and prediction systems (eg BIOCLIM, Booth *et al* 1988) has enabled the prediction of rare fauna (eg Longmore 1986, Dovey 1987), and potential pest distributions (Van Beurden 1981). The use of such schemes encourages the efficient use of survey and research time and speeds up the mapping of distributions.

The factors governing the distribution of species must also be understood as distributions change with time (Bowers 1986, Rosenweig and Abramsky 1985). Thus an understanding of distributions, and of the factors influencing vulnerablity must be available to ensure that guidelines for the effective management of vulnerable species can be implemented.

Key Taxa

Taxa that fruit, flower or seed outside community peaks in production or that provide other specific habitat requirements may be extraordinarily important in maintaining sedentary vertebrate populations. These have been designated "keystone mutualists" (Leighton and Leighton 1983 after Gilbert 1980) and are referred to as key taxa in this paper. Any species, the removal of which would precipitate significant losses of other species should be considered a key taxa. In a situation of limited resources, those species most critical to the maintenance of a diverse community or crucial to the maintenance of vulnerable species should be targeted first for research and management effort. The identification of these species requires a knowledge of interactions within a system and of species responses following disturbance.

Gastrolobium bilobum (R BR, 1811) is a key taxa in the Perup Nature Reserve where it forms thickets suitable as habitat for the tammar wallaby (Christensen 1980). Specific management operations are necessary to ensure the continued maintenance of suitable habitat for the tammar wallaby in this reserve. In this example, maintaining suitable habitat requires burning prescriptions to produce intense fires under controlled conditions.

Rare species, vulnerable species and key taxa should all be given high priority in the management of fire on nature conservation lands. Species that fit all of these categories are of the greatest priority (eg certain species of Banksia which flower at a time of limiting food resources in a community, are also rare, susceptible to dieback caused by Pythiaceous fungi, and are fire sensitive obligate seed regenerators).

The Role of Monitoring

Monitoring programs are necessary to detect changes that relate to all components of the ecosystems being managed. However, such programs tend to be of little scientific or practical value unless accompanied by corresponding environmental information that allows the process responsible for change to be identified. Similarly, the monitoring must have an explicit hypothesis to be successful in determining whether criteria are being met. It follows that the organism appropriate to the hypothesis should be identified and monitored (see Ridsdill-Smith 1986).

Monitoring of particular species will be of advantage if a relationshp exists between the abundance of several species at any time. Thus low numbers in one species may suggest reason for concern in others. The spatial variation in density and thus comparative suitability of monitoring sites should be known before the establishment of monitoring programs.

Figure 2 shows trapping results in three years in two reserves known to include populations of the Woylie (*Bettongia penicillata* Gray, 1837), common Brushtail Possum (*Trichosurus vulpecula* Kerr, 1792) and Southern Brown Bandicoot (*Isoodon obesulus* Shaw and Nodder, 1797). Different trapping rates for woylies in the two reserves suggest different sized populations. However, population sizes are not static suggesting a need to plan operations designed to manipulate habitat around trends in population levels. Species vary in the ease with which they may be studied and monitored. Efficiency in monitoring time and effort will be achieved if high population densities of easily trapped animals such as the woylie (eg) reflect high populations in other species.

TRAPPING RESULTS FROM TWO RESERVES SHOWING SIMILAR TRENDS IN NUMBER OF ANIMALS TRAPPED

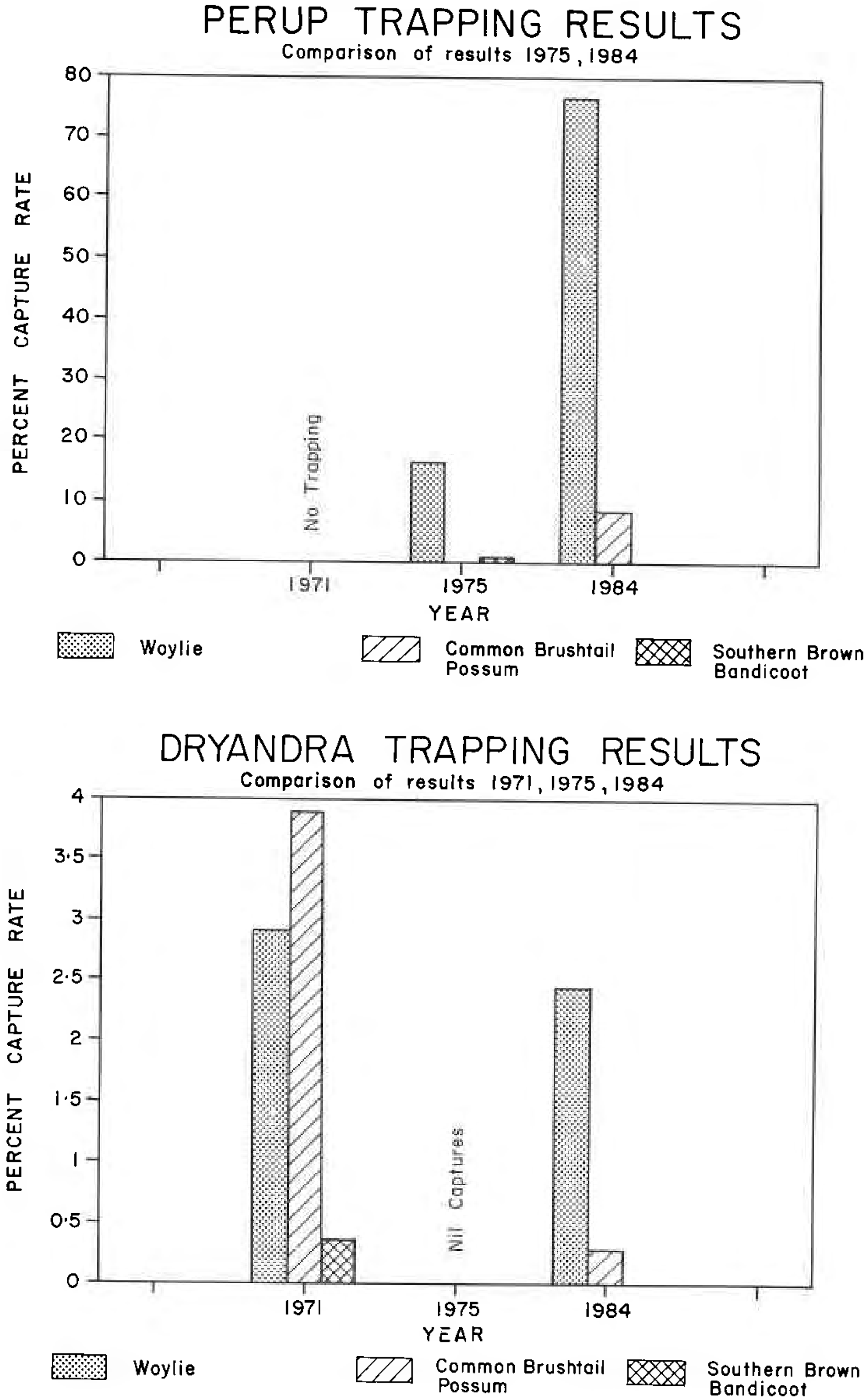


FIGURE 2
Trapping results using box traps in three years in the Perup Nature Reserve and Dryandra State Forest.

Interactions Between Fire, Reserve Users and Neighbours

Management of fire is influenced by political and social factors and objectives for reserve management reflect society's prevailing attitudes and ideas. The cultural environment therefore has considerable influence on the detail of management practices. Major changes in the attitudes of the community towards fire have taken place in the last 150 years in south-western Australia (McCaw and Burrows 1988) and such changes will no doubt continue in the future, probably at an accelerated rate.

Government agencies responsible for management of conservation lands generally must comply with a wide range of legislation. These Acts are therefore an essential part of the critical data requirements. For fire management of conservation lands in Western Australia the Conservation and Land Management Act (1984) and the Bushfires Act (1954) are particularly important. The Wildlife Conservation Act (1950) also contains important provisions relating to the protection of declared rare flora from fire.

Many conservation reserves experience a variety of additional land uses which may range from passive recreation to mining; illegal activities such as wildlife poaching may also occur in some cases. Information about the distribution, extent, nature and timing of these activities is critical, both for determining the risk of ignition posed by these activities, and for determining the degree of hazard to which land users may be exposed during fire. Regular updating may be required if land use patterns are changing rapidly; visitor surveys, regular patrols and periodic remote sensing may all play a role in keeping the data base up to date.

All reserves have neighbours, whether they be private landholders, shires, other government agencies or the Crown. To be effective fire management must be planned on a regional basis, and for this reason the attitudes and policies of neighbours towards fire may have an important bearing on management of fire in a reserve. Effective liaison and participation with volunteer bushfire brigades, local authorities and public interest groups should be fostered as a means for gauging local opinion. In many cases reserve managers may be able to obtain much useful information about a reserve from local people with long experience in the district.

Resources Relative to Management Objectives

Many factors limit the capacity of managers to undertake all fire management operations considered desirable and so priorities must be assigned to ensure that resources are deployed efficiently. Systematic evaluation of the risk of fire ignition and of the hazards posed by fire to different values provides a logical basis for allocating priorities. Hazard rating systems have been developed for national parks in Eastern Australia (Good 1985) and forest areas in Western Australia (Burrows personal communication, Underwood personal communication). Once maps of relative hazard can be generated for individual reserves, priorities can be allocated for modifying or reducing the level of hazard or increasing the opportunities for fire control. Hazard reduction is often considered by some to be synonomous with fuel reduction burning but this need not be the case. Alternatives range from employing other means of fuel modification to relocation of the asset itself away from the perceived hazard, or upgrading fire detection and suppression capabilities.

Management in the Absence of Data

The critical data set suggested here may take some years to compile even for a single reserve. Similarly, data not currently considered critical to fire management may become so as the objectives of fire management of reserves develop. However, management must continue, even in the absence of critical data and interim plans are therefore essential. Necessary management operations can continue even while we know little of the biological pattern and processes of the reserve. However, in such a situation, managers must be conservative in their approach. The following strategies should be employed to minimise disturbance while a more complete understanding of the role of fire in the maintenance of ecosystems is developed:

1 Oppose or defer disruptive activities or interventions where the outcome is uncertain (eg mining, damaging recreational use, activities encouraging weed or pest invasion or major changes to hydrology). Avoid undertaking large scale operations pre-emptive of a management plan (eg major new roadworks).

2 Repair the scars of any previous disruptive activities (eg rehabilitate gravel pits, close poorly sited access tracks, ensure good demarcation between neighbours with different land use policies). Remove undesirable weed or pest species where this does not compromise other conservation objectives.

3 Prevent the entire area of any single community type being burnt at the one time.

4 Liaise with neighbours; encourage an interest in the reserve. Ensure a thorough public involvement in the final management plan process.

5 Encourage the gathering and dissemination of a critical data set for the reserve.

6 Ensure that there is sound justification for every management operation and that the effectiveness of all operations are documented and monitored.

7 Be prepared to move with the times and update management plans as new information comes to light.

8 Adopt a strategy of experimental management (Gill 1986, Hopkins and Saunders 1987) where variations of current operations are tested in areas of greatest resilience. Examine methods of hazard reduction that have the least impact on the biota.

CONCLUSION

Until recently fire management plans have primarily addressed the protection of human values and the management of particular species. With greater public interest, wider knowledge and more sophisticated objectives there is a requirement for more holistic management. This will necessitate a more structured and systematic approach to data collection and analysis. It is therefore essential to define those aspects of the biological, physical and cultural environment that must be researched first to ensure that management concentrates on key issues and is able to become more sophisticated as the needs increase.

Data that aids our understanding of fire regimes and the response of the biota to those regimes are considered critical. Cultural data on the interactions between fire, reserve users and neighbours and the priorities for resource allocation will determine the success of the management of fire on nature conservation lands and must also be considered critical. In the absence of these critical data requirements conservative management strategies should be adopted to ensure minimum disturbance to ecosystems until reliable data on which alternative approaches may be based, are available.

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